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Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S.,
DIRECTOR.

REPORTS

OF

GEOLOGICAL EXPLORATIONS

DURING 1876-7.

WITH MAPS AND SECTIONS.

PUBLISHED BY COMMAND.

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ERRATA.

Page VII., line 11—For *ventebræ* read *vertebræ.*

Page 1, line 13 to 15—For Pliocene { Old plain deposits / Awatere = Wanganui / Kanieri = Taipos }

read { Pliocene — Old plain deposits / Miocene { Awatere = Wanganui / Kanieri = Taipos } }

Page 3, lines 5, 6, 11, 18, 33—For *Clint* read *Clent.*
Page 3, line 35—For *silicious* read *siliceous.*
Page 6, line 3—For *regnlar* read *regular.*
Page 8, line 28—For *Otatara* read *Ototara.*
Page 14, line 24—For *rests* read *rest.*
Page 15, line 11—For *equivalents* read *equivalent.*
Page 16, line 8—For *Eoeene* read *Eocene.*
Page 21, line 22—For *fosils* read *fossils.*
Page 21, line 32—For *Turbenolia* read *Turbinolia.*
Page 28, line 7—For *erruption* read *eruption.*
Page 37, line 20—For *feature* read *fracture.*
Page 41, line 2—Read *by Dr. Hector.*
Page 48, line 5—For *one* read *ones.*
Page 61, line 1—For *These contain* read *It contains.*
Page 61, Foot-note—For *strangely* read *strongly.*
Page 65, line 35—For *point more to the north* read *point, more to the north.*
Page 66, line 1—For *flaws* read *flows.*
Page 69, line 32—For *old, secondary* read *old secondary.*
Page 85, line 3—For *bouudary* read *boundary.*
Page 85, line 30—For *Ii* read *It.*
Page 87, line 12—For *Mangatinoho* read *Mangatinoko.*
Page 93, line 18—For *alterations* read *alternations.*
Page 100, line 36—For *equivalaent* read *equivalent.*
Page 107, line 11—For *Te Kaka* read *Te Kaha.*
Page 114, line 20—For *vid* read *viz.*
Page 116, line 32—For *buttoned* read *bottomed.*
Page 118, lines 23 to 29—Omit „ below *Leda.*
Page 119, line 26—For *Pukokohe* read *Pukekohe.*
Page 121, last line / Page 122, line 12 —For *Leda, marls* read *Leda marls.*
Page 135, line 5—For *analysie* read *analysis.*
Page 143, line 23—For *throught* read *through.*

PROGRESS REPORT, 1876-77.

The field-work which has been carried on by the Department during the past year has been productive of some very important results.

From the notes which have been made by officers of the Department, together with information gained by the study of collections of fossils from various localities with Professor Etheridge while in England last year, and a subsequent careful examination by myself of the large collections now in the Museum, I have been enabled to draw up the following classification for our fossiliferous rocks, which, for convenience sake, is published in a tabular form, comparison thus being readily made between it and the classification adopted in the geological map of 1873, and also that suggested by Capt. Hutton in his "Geology of Otago," 1875.

In this new classification, which will be adopted by the Department in future, it has been thought advisable to give locality names to the beds, such names being chosen from well determined localities mentioned in the reports.

Geological Map, 1873.	New Classification, 1877.	Capt. Hutton's Classification, 1875.
Post Tertiary (Recent)—	*I. Recent and Pleistocene*—	*Quarternary (Recent and Pleistocene)*—
a. Turbary deposits *b.* Lacustrine deposits *c.* Littoral deposits	*a.* Moa beds *b.* Alluvia *c.* Raised beaches, moraines, &c.	*a.* Recent deposits
Drift Formation (Post Pliocene and Newer Pliocene)—	*II. Pliocene*—	
a. Pumice terraces *b.* Gravel terraces *c.* Extended moraines *d.* Tufaceous clays	*a.* Terrace plains, Scinde Island limestone	
**e.* Older gold drifts *f.* Lignitiferous deposits	*b.* Pumice Sands and lignite series *c.* Kereru Rotella beds, Motanau, &c.	Pleistocene deposits (Upper Wanganui beds) Newer Glacier deposits

* These beds have since been shown to belong to the horizon of III. of the Taerua or Ross beds.

Geological Map, 1873.	New Clastification, 1877.	Capt. Hutton's Clssifiction, 1875.
Marine Tertiary (Pliocene-cretaceous)—	*III. Upper Miocene—*	*Newer Pliocene—*
a. Wanganui and Awatere series	*a.* Wanganui series (Older gravels of South Island.)	Wanganui formation (Shakespeare Cliff)
		Older Pliocene—
		Older Glacier deposits
	b. Manawatu Gorge *c.* Castle point *d.* Taerua & Ross (Older gravels of South Island.)	
	e. Waitotara and Awatere beds	*Upper Miocene—*
		Pareora formation (in part)
	IV. Lower Miocene—	
	a. Mangapakeha Valley	
b. Hawke's Bay and Kanieri series	*b.* Taipos, Awamoa and Pareora beds	Pareora formation (in part)
	V. Upper Eocene—	*Lower Miocene—*
	a. Mount Brown beds	Oamaru formation Trelissic Group (in part)
	b. Hutchinson's quarry beds *c.* Nummulitic beds	Oamaru formation (in part)
Ototara series (in part)	*VI. Cretaceo-tertiary—*	
c. Ototara series	*a.* Cardita beds / Grey marls	Oamaru formation, Ototara Group
	b. Ototara and Weka Pass stone	
d. Aotea and Cobden series	*c.* Fucoidal greensands *d.* Chalk marls and Amuri limestone	Pareora formation (in part) Otepopo, Kokohu, Waiho
e. Shag point series	*e.* Marly greensands *f.* Island sandstone (Reptilian beds)	Oamaru formation (in part) Waitaki, Green Island, Waihola, Lake Wakatipu, Morley Creek
		Secondary, Upper Cretaceous—
Coal Formations— *a.* Upper brown coal *b.* Lower browncoal *c.* Grey coal series	*g.* Coal formation and black grit	Waipara formation (in part)

Geological Map, 1873.	New Classification, 1877.	Capt. Hutton's Classification, 1875.
d. Waipara series	*VII. Lower Greensand*— Amuri group	Waipara formation (in part)
Jurassic— *a.* Mataura formation *b.* Putataka formation *c.* Clent Hill formation	*VIII. Jurassic*— *a.* Mataura series *b.* Putataka series	*Lower Jurassic*— Putataka formation
	IX. Lias— *a.* Catlins River *b.* Clent Hills	
Triassic— *a.* Wairoa series	*X. Trias*— *a.* Wairoa series *b.* Te Anau series	Maitai formation
Upper Palæozoic— *a.* Te Anau series *b.* Maitai series *c.* Rimutaka series	*XI. Permio Carboniferous*— *a.* Maitai series, Nuggets and Mt. Potts	Kaikoura formation
d. Mt. Arthur series	*XII. Devonian*— *a.* Reefton beds *XIII. Silurian*— *a.* Mount Arthur beds	Kakanui formation

The only examination of strata older than the coal made during the year was of the Lower Mesozoic Rocks, at Waikato Heads and the Kapamahunga Range, by Mr. Cox, and a brief examination which I made of the well developed members of the same formation in the Hokanui Ranges, in Southland.

Here the following sequence is well displayed in the natural sections obtained by following up the Otapiri Creek to its western sources, and thence across the range to the New River flats, at Benmore.

The stratigraphical sequence appears to be perfect, although several distinct formations are represented, and the whole group forms a flat syncline, the main axis of which dips at 7° to the east.

The sequence is as follows :—

MATAURA SERIES.	*(a.)* Grey Sandstone (Astarte beds). *(b.)* Argillaceous Sandstone (Coal and Pecopteris beds). *(c.)* Concretionary Sandstone (Plants). *(d.)* Grey Sandstone, with round pebbles dispersed. *(e.)* Coarse Conglomerate of Granite Pebbles (Tœniopteris beds). *(f.)* Dark Green Earthy Shales (Ammonite beds)?
PUTATAKA SERIES.	*(g.)* Jointed Limestone, weathers red (Pholadomya beds). *(h.)* Red Calcareous Shales. *(i.)* Dark Green Calcareous Breccia and Grit, almost limestone (Spirifer beds).
WAIROA SERIES.	*(k.)* Blue and Red Marly Shales. *(l.)* Green Sandstone (Cannon-ball Sandstone, of Haast). *(m.)* Monotis Sandstone. *(n.)* Concretionary Coarse Sandstone. *(o.)* Conglomerates (not very coarse), Slate, and sometimes Quartz Pebbles.

MOUNT SOMERS DISTRICT.

During November, 1876, Mr. Cox was employed in an examination of the Mount Somers District, in order to revise the arrangement of the strata in this interesting locality with our latest knowledge.

He describes the following sequence as characteristic of the younger beds that overlie the coal :—

1. Flaggy Limestone.
2. Compact Limestone (Mount Somers building stone).
3. Basalts and Tufas.
4. Greensands (with included fragments of vesicular lava).
5. Marly Limestones (with Echinoderms).
6. About 100 feet (not seen).
7. Shell Limestone and Calcareous Grit (with numerous casts of shells).
8. Glass-making Sands, coloured with light hues.
9. Quartziferous Porphyries.

He considers that beds Nos. 1 and 2 represent the Mount Brown limestone; Nos. 3 and 4 are the equivalents of the Eocene volcanic rocks, at Oamaru, and below this point a palæontological break occurs, which is represented stratigraphically by the overlap of these upper beds; bed No. 5 he considers as the equivalent of the *Leda* marls passing down

into the concretionary green-sands and Saurian beds of the Amuri Bluff section, with the upper part of the coal series occurring at their base.

The existence of two distinct seams of coal is pointed out; one older than the acidic series of Mount Somers', the other of much more recent origin, lying in basins or hollows excavated in the above named rocks.

With reference to the age of the Mount Potts beds, which I formerly placed in the Wairoa formation on account of the supposed association of the Clent Hills Tœniopteris beds, and from the presence of Saurian remains, which I referred to "Ichthyosaurus australis." *

I have since compared the ventebræ obtained at Mount Potts with those described from the carboniferous rocks of Nova Scotia by Professor O. C. Marsh † as "Eosaurus acadianus," and feel confident that they must be referred to the same genus. Consequently the Mount Potts spirifer beds have been placed in the Maitai formation along with the Nugget Beds, there being now no reason for giving to them a higher horizon.

Waikato District.

During December, 1876, and January, 1877, Mr. Cox was employed to make an examination of the Belemnite and Plant beds of the Waikato Heads, and also further to examine the calcareous strata of the Waikato basin.

The results obtained by this trip have been to add fresh data for the elucidation of the following problems :—

1st. The age of the fossiliferous beds at the Waikato Heads, and their relation to the Plant beds in the same locality.

From these beds, at their typical point of occurrence, a large collection of fossils was made, comprising however but few specific distinctions. Amongst these may be mentioned Aucella plicata, two species of Inoceramus, Belemnites, Placunopsis, and an Ammonite, with a doubtful specimen of Halobia. In character they present a striking resemblance to certain beds which occur between Raglan and the Kapamahunga Range, flanking which, and underlying the above beds, decomposing micaceous sandstones occur, containing Monotis in large quantities, and representing the Wairoa series as developed at Nelson.

This is the first locality in the North Island in which these beds have been found, and they are of interest as giving additional evidence

* Trans. N.Z. Inst., Vol. VI., p. 355.

† Amer. Journ. of Science XXXIV.

as regards the relations between them and the slates which they overlie unconformably.

Above the Aucella beds, and quite conformable with them at the Waikato Heads, come a series of Plant beds about 1,000 feet thick, the organic remains from which can in no way be distinguished from those obtained from the Mataura Plant beds. They consist of the following sequence in descending order :—

1. Sandstone.
2. Belt of Slate Conglomerates.
3. Slate, interbedded with Sandstone.
4. Hard Grey Sandstone.
5. Banded Slates (Plant beds).
6. Concretionary Sandstone (50 feet thick).
7. Hard Grey Sandstone, with marly and slaty beds.
8. Sandy Marls (Plant beds).
9. Slates, with indistinct plants.
10. Marls, with bands of hard grey sandstone.

With regard to the relation of the coal to the higher calcareous beds, Mr. Cox does not consider that any unconformity occurs between them until reaching the higher part of the grey marls; and where higher beds than these are met with, any break which may occur will be more dependent upon palæontological than stratigraphical evidence, as the grey marls, both at Te Hara Point and the Waikawau Creek, are overlaid to all appearance conformably, by blue marls with fossils passing into sandstones, and at Te Hara Point being capped by limestones, from which large collections are at present in the Museum.

These beds, at Waikawau Creek, and also certain light coloured marls and loose sands occurring at Mercer, have hitherto, owing to the absence of fossil collections, been grouped together under the title of Waitemata beds; but the collections which have now been made from these localities, renders it necessary to separate them. The beds of Waikawau Creek represent the highest member of the grey marls, and as they contain, amongst other fossils, a large cardita that cannot be distinguished from "Cardita planicostata" of Europe, they are probably of Lower Eocene age. On the other hand, the beds at Mercer take the position of the highest part of the *Leda* marls in the Waikato basin, passing down in regular sequence through them to the coal—a typical section of which can be seen at Mr. Foote's mine, on the edge of the Maramarua Swamp.

Oamaru and Waitaki District.

During November and December Mr. McKay made a special trip of a few days to the Waipara, after which he left for Oamaru, the district surrounding which he had been instructed to examine and collect from.

He has made magnificent collections from six of the most important localities, besides a number of smaller, but not less important ones, elsewhere. The results of his work may be briefly summed up as follows:—

Cretaceo-tertiary.

Grey Marls.—These beds, forming the upper members of the group, which are of a great thickness along the east coast of the northern part of the South Island, gradually thin out farther south, until on the S.E. side of Mount Grey (Canterbury), they are not more than 100 feet thick; and south of this point they cannot be recognised, unless certain beds overlying the Maraewhenua limestone, in the Waitaki Valley, should be proved to belong to this horizon.

Weka Pass Calcareous Greensand.—Below the grey marls, in the north of Canterbury, the Weka Pass calcareous greensand occurs, of which, in N.E. Otago, the Maraewhenua limestone and Ototara building stone are the equivalents.

Tertiary.

Above the grey marls the following beds are met with:—

Mount Brown limestone, White Rock Quarries (on the Okuku River), the Curiosity Shop beds, Hutchinson's Quarry beds (at Oamaru), the Kakanui limestone, and the volcanic rocks of Oamaru Creek, and the Cape Hills (Oamaru).

These higher beds it has been found impossible to separate, either stratigraphically or otherwise, from the Awamoa series (Pareora beds), which overlie them, whilst between this and the underlying cretaceo-tertiary series unconformity is to be observed at several points, as in the Cape Hills (Oamaru), and at Cape Campbell (*vide* report on that district), although it may be doubted whether the Awatere beds, which there rest unconformably on the cretaceo-tertiary series, are the true equivalents of the Awamoa beds, or of Upper Miocene age. Apart from this, however, the character of the volanic rocks, at Oamaru, as evidencing the existence of a land surface, together with the superior position to these of the calcareous beds of Hutchinson's quarry, with the Awamoa beds resting conformably on them in Limekiln Gully, sufficiently attest the unconformity, which is further supported by the

occurrence of an outlier of Awamoa beds resting upon the green-sands and coal grits in the Waiareka Valley.

General Remarks.

From the table which will be found in the early part of this report it will be seen that the Trelissic Group of Capt. Hutton's Oamaru formation will have to be placed at the base of the Awamoa (Pareora) beds, as seen in their respective districts, an unconformity separating these beds from the Oamaru stone and the underlying tufas and green-sands on which they rest indifferently.

On the other hand, certain localities considered by Capt. Hutton to belong to his Pareora formation, have been shown to belong to the greensands and Saurian beds immediately overlying the coal: for instance, in the lower part of the Otepopo River, where all the beds present underlie the Ototara stone; and in the Kokohu River, where the fossils are identical with those from Black Point, in the Waitaki Valley, in which latter place Ancyloceras and Baculites are found, together with somewhat doubtful remains of Belemnites.

The coal beds of the Kohohu River and Otepopo have been shown to belong to a horizon below the Saurian beds of Amuri Bluff and Waipara, and to be the same as the coal beds of Shag Point, although Capt. Hutton places them at the base of his Oamaru formation. The lower members of these beds are of special interest, as they form the matrix from which the alluvial gold is obtained at the Maraewhenua gold workings in the Waitaki Valley—a circumstance which gives a prospect of some extent of auriferous country throughout Otago which is yet unworked.

Masterton and Napier Districts.

In the early part of the present year Mr. McKay was despatched to the Manawatu Gorge to collect data for the determination of the relations between the calcareous sands and conglomerates at the upper end of the Gorge, the underlying beds in the Forty Mile Bush, and the overlying beds in the Seventy Mile Bush, which led to a partial examination of the country as far as Scinde Island, and along the flanks of the Ruahine Range to the Ngaruroro Gorge.

The limestone of the Manawatu Gorge is the same as that which flanks the east side of the Wairarapa Valley, and in its northern continuation forms the Puketoi Range, the clays which underlie, with loose sands, forming the base of the series over a great extent of country, resting upon the secondary and Palœozoic rocks.

Thus, in this district, no relation between these beds and other tertiary rocks can be traced; but, when the country between Masterton and the Wharehama Valley is examined, the inference is that they will be found to overlie the Taipo beds unconformably, since no trace of the Taipo beds is seen in the neighbourhood of Castle Point, the limestones and underlying clays there resting upon the upturned edges of the secondary rocks.

The limestones of the Manawatu Gorge are at many places overlaid conformably by sands and clays full of fossils, which in every respect agree with those obtained from the lower part of Shakespeare Cliff, and which are followed by another series of conglomerates, sands and clays, with large deposits of pumice sands, the Scinde Island limestone appearing at the top of the series.

The relations between these limestones of Scinde Island and those of the Manawatu Gorge are not very clear, but it seems probable that an unconformity exists between them, as otherwise it would be difficult to account for the section shown between Cape Kidnappers and the Ngaruroro Gorge.

A remarkable circumstance in connection with these beds is, that up to the horizon of the pumice sands they have suffered an amount of disturbance in places, not usually observed in beds so young, the Manawatu limestones along the flanks of the Wakarere Range being at times completely overturned.

The general results of this examination are that the Scinde Island limestone of Napier is shown to be the highest marine bed in the district, being separated from the limestones of the Puketoi Range and Manawatu Gorge by a great series of fossiliferous sands and clays, estimated in the district west of Napier to be not less than 2,000 feet thick, while the lower limestone is itself separated from the series of sandstone, &c., forming the Taipos, by a great but undetermined thickness of strata; two unconformities probably occurring between the Taipos and the Scinde Island Rocks.

From these observations it is apparent that the whole of the beds examined cannot be held together under the designation of the Ahuriri formation, as proposed by Capt. Hutton, since the rocks so associated comprise members of, at least, three different formations, the lower beds belonging to the Awamoa series (the Pareora formation of Hutton), whilst the higher beds are equivalent to the formation seen in the higher beds of Shakespeare Cliff, Wanganui.

WANGAREI.

In March Mr. Cox examined the beds in the neighbourhood of Wangarei, and made collections from the fossiliferous beds of Tiger Hill and underlying green sandstone which forms the roof of the coal where met with.

The fossils obtained from these beds serve to correlate them with the Island sandstone overlying the brown coal of the West Coast, the brown sandstones of Tiger Hill representing the *Leda* marls and overlying beds up to the horizon of the grey marls, an outlying patch of which beds occurs between Wangarei and Mangapai. The coal of this district, which can be traced more or less continuously from Wangarei to Kawakawa, appears to be cut out or replaced on the eastern side of the slate ranges by a second limestone, in a similar manner to several other localities in the colony. Mr. Cox considers the trachytic series of Wangarei Heads to be the equivalents of similar beds which occur at Cape Runaway, and from there to Hick's Bay, and which he examined immediately after leaving Wangarei during the month of April.

In this last locality the trachytes are distinctly overlaid by the oyster bed, which forms the lowest member of the Tawhiti series, and consequently they cannot be considered to be of less age than Upper Eocene. Between Opotiki and Whangaparau a development of the Mataura series has been traced, these probably representing the lower beds of the Poverty Bay oil rocks. They seem, from their position on the coast, to strike back to form the mass of Hikurangi, and they rest unconformably upon an older slate series, which reaches the coast line at Raukokore. The examination of this district was made with a view of connecting the beds here with those mapped between Poverty Bay and the East Cape during the season of 1873-74, with which the present work well agrees.

With regard to the coal measures throughout the colony, the following brief summary gives the results which have during the past year been gathered by members of the Department, and also by labour employed under the vote for coal explorations :—

Since Mr. Cox's report on the survey of the Buller Coal Field, published as an appendix to the Public Works Statement of last year, the work in that locality has been completed, and the maps of the district are now ready for circulation.

The detailed reports and plans of the various coal areas appear in the Geological Reports for the current year, and a brief summary of the results is herewith given.

Since the completion of that survey, and during the current year, the same assistants have been employed on an examination of the Northern coal fields, including Waikato, Wangarei, and Bay of Islands, and have also completed surveys of the Green Island Collieries, which were previously being worked without any plans whatsoever of the mines.

A further report has also been obtained on the Kanieri Coal Field, and on the present condition of the Greymouth collieries; and the results of this survey appear in detail, with other work of a similar description, in the Geological Reports of this year.

The following brief summary gives the leading points of interest in connection with the various mines which have been examined, and country explored during the time above specified:—

KAWAKAWA, BAY OF ISLANDS.

The coal at this mine is worked by an engine-dip, the extended workings being wrought upon a system of square work.

This excellent coal seam varies in thickness from 6 to 10 feet, and holds steadily until a fault is met with, having a down-throw to the south, estimated to be about 70 feet.

On this down-throw area the future permanent workings of the mine will depend, and the opening of this area will have to be undertaken shortly, as the engine-dip and lower level are now driven to about the water level of the present pumping shaft, and the surface water is breaking through a backing in the roof near this level, and all but overpowering the present pumping gear.

The future working of this mine will necessitate a shaft being sunk to the dip with heavy pumping gear, as pointed out some time ago.

WANGAREI.

Whauwhau Colliery (Walton's Mine).—This mine, which was formerly worked by Walton and others as a dip working, on an ordinary system of square work, the coal being raised by an engine plane, was abandoned by them, the water having overpowered their pumping appliances.

A party of working miners have since taken it up, and, after driving a tunnel for a distance of 19 chains through a slate bar, have cut the coal, and are now able to work it level free.

The coal seam worked by this Company is from 6 feet to 10 feet thick, and of fair quality.

Kamo Mine (Meldrum's).—This is a small and very irregular tunnel

working. The coal seam is from 8 feet to 10 feet thick, and it is probable that this seam is the same as that which has been found at Whareora, although the nature of the country between these two outcrops is such as to render the tracing of the coal by surface indications impossible.

Whareora.—Two outcrops of coal are known in this locality of 3 feet and 3 feet 6 inches thick respectively, but no explorations have been undertaken with regard to this coal beyond entering a drive for a few feet on one of the outcrops, and having some assays of the coal performed.

Some samples of coal from this locality are remarkably good, but the quality varies, as is also the case in the Whauwhau and Kamo Mines; and as the position is unfavourable, nothing would be gained by opening a mine here at present.

Hikurangi.—A considerable coal area may be looked for in this locality, the thickness of the seam varying from 2 feet to 6 feet. It may be traced from the summits of the slate ranges towards the swamp at the base of Mount Hikurangi, and may be looked for as occupying the low-lying ground there.

The coal from this locality has been used by the blacksmith in Wangarei with considerable satisfaction, and would appear to be of a somewhat better quality than the rest of the Wangarei coals.

Awaroa Creek.—Several bore-holes have been put down here with a view of discovering coal near the edge of the harbour, but up to the present time with no success; and the coal appears to be replaced here by a lower belt of limestone.

Waikato District.

Bridgewater Colliery (Foote's).—The winning of this coal has only been recently commenced, but a seam of coal 55 feet thick has been struck in the main shaft, and a level, heading south from this shaft, has reached a point below the Maramarua Swamp, at the edge of which the shaft was sunk. In association with this coal seam three valuable bands of iron-stone have been discovered, yielding about 40 per cent. of metallic iron.

Rahuipokeka (Ralph's) Mine.—This mine is situated on the east bank of the Waikato River, at the base of the Taupiri Ranges, and is wrought by a tunnel, upon an irregular system of square work. The portion of the seam of coal worked at present is 18 feet thick, and is the same seam as that which occurs at Foote's Mine. The workings were

rising on the coal, and recently a further thickness of 13 feet has been proved by sinking on the then floor of the coal, which proved to be only a band of blaze, three feet thick.

Kupakupa Mine.—This mine is situated on the western side of the Waikato River, opposite Ralph's Mine, but at an elevation of 130 feet above the level of the river, and about 100 feet higher than Ralph's coal, indicating an up-throw fault to the westward.

The average thickness of the coal is 18 feet, and the mine, which is worked upon a true system of square work, is in very satisfactory order.

A careful examination of the coal formation in the Waikato district, and the relations which it bears to the overlying strata, renders it not improbable that the coal seam extends continuously throughout the greater part of this basin between Mercer and Taupiri, and flanked to the eastward by the slate range which runs from the Firth of Thames to Taupiri, and thence to Ngaruawahia. The truth of this can easily be proved by a bore-hole, three sites which might be chosen being pointed out by Mr. Denniston in his report—viz., Churchill, Pungapunga, or Mercer, but Churchill would, for several reasons, be the best of these localities.

Buller Coal Field.

Maps of this district are issued by the department in sheets to accompany Geological Reports, showing all the known coaliferous areas between Westport and the Ngakawau River; and Mr. Denniston's report gives 195 sections which have been observed throughout this coal field. The areas holding coal have been carefully laid down, and may be depended upon. No plans of the surveys for leases have been forwarded to the department, so that these do not appear on the map, and the following estimate of the quantity of the coal can only be given, in consequence, for the natural divisions which it would be most advisable to adopt in working the field, and which are indicated in the map attached to Mr. Denniston's report :—

	Approximate Extent.	Average Thickness.	Workable Coal, in Tons.
Area 1	500 acres	13 feet ...	4,875,000
Area 2	860 ,,	7 ,, ...	4,515,000
Area 3	640 ,,	4 ,, ..	1,920,000
Area 4	1,500 ,,	17 ,, .	19,125,000
Area 5	900 ,,	23 ,, ...	15,550,000

	Appropriate Extent.	Average Thickness.	Workable Coal, in Tons.
Area 7	100 acres	15 feet ...	1,687,500
High Level A	300 ,,	17 ,, ...	3,825,000
High Level B	75 ,,	17 ,, ...	956,000
High Level C	100 ,,	14 ,, ...	1,050,000
Low Level C	122 ,,	12 ,, ...	1,098,000
High Level D	300 ,,	15 ,, ...	3,375,000
Mid Level D	1,105 ,,	15 ,, ...	12,431,250
Low Level D	455 ,,	20 ,, ...	6,825,000
Mid Level E	420 ,,	14 ,, ...	4,410,000
Southern edge of Waimangaroa Gorge	90 ,,	6 ,, ...	450,000
Mount William	180 ,,	15 ,, ...	2,025,000
Todea Creek	225 ,,	25 ,, ...	4,218,750
Coalbrookdale	600 ,,	12 ,, ...	5,400,000
High Level of do.	770 ,,	9 ,, ..	5,197,500
Mount Rochfort	200 ,,	4 ,, ..	600,000
Lower Waimangaroa ...	1,200 ,,	9 ,, ...	6,000,000
Total	...	...	105,034,000

Up to the present time the only mine which is in active operation is that of the Wellington Coal Mining Company, situated at the foot of Sims' Spur, on the northern side of the Waimangaroa River, from which mine the first shipload of coal has been despatched for Wellington. The coal from this mine is soft, but otherwise its quality is all that can be desired for a good steam coal, and the coke which is made from it is inferior to none.

Several other companies are moving in the matter, but up to the present time no active operations have been undertaken, save that the Koranui Company have had a survey made for them, with a view of discovering the best route for a tramway; and Messrs. Fisher and Co. have had a tramway laid out to the face of their coal, to connect with the branch line of the Wellington Company.

Grey River Coal Field.

Brunner Mine.—During the last three years the workings of this mine have been increased from 22 acres to 38 acres in extent, with a total output for the four years of 49,823 tons. The coal is now conveyed to Greymouth by rail.

Six coke ovens have been constructed for this mine, and a very superior coke is produced, a half-burnt variety, known as black ends, being used locally for the locomotives on the Brunner Railway.

Coal Pit Heath.—This lease adjoins the Brunner Mine, and a shaft has been sunk, cutting coal of a good quality, and somewhat

harder than that of the Brunner Mine, at a depth of 265 feet. This shaft was expected to be ready for working in a few weeks when the mine was visited in March last, and the Company are now bringing their coal to market.

Greymouth Coal Company.—A shaft has been sunk on this property, cutting a 16 foot seam of coal at a depth of 635 feet, but up to the present time no coal has been worked. The first shaft which was put down was too near a fault, and the coal struck also proved to be very inferior in character. Samples forwarded to the Department from the present seam prove the coal to be of very superior character and hardness.

Coal Creek Company.—Two seams of coal of 6 feet and 10 feet thick respectively are known on this lease, being separated by about 170 feet of light-coloured sandstone. This coal will have to be worked by a special line, which the promoters propose to construct to connect this mine and the Point Elizabeth seams with Cobden.

Point Elizabeth Coal Mining Company.—Several outcrops of coal 4 feet to 16 feet thick are known in this lease of 3,840 acres, of first-rate quality. Up to the present time no attempt has been made to open up the mine. The extent of the coal is proved sufficiently to warrant the mine being opened, and with so large an area as is held by the Point Elizabeth Coal Mining Company the output should be very large.

HOKITIKA.

Kanieri Prospecting Association.—No fresh evidence has been gained of the existence of workable coal seams at the Kanieri, and the prospects in that district do not warrant any further expenditure being gone to by the Government for coal exploration.

GREEN ISLAND, OTAGO.

The following collieries are at present at work at Green Island :—The Otago Colliery, the Freeman's Colliery, the Samson's Colliery, the Walton Park Colliery, and the Saddle Hill Colliery.

Somewhat extensive workings are being carried on in each of these mines, but up to the time when they were visited during this year not one of them was in possession of a plan of their workings.

Surveys have now been made of all the workings which are still accessible ; but the inattention on the part of the proprietors of these collieries to the safety of the miners, and also to the proper working of the coal with the ultimate prosperity of the mines in view indicated by the want of plans, is most reprehensible, and requires some rules to be

made, which shall compel proper attention to the interests of the colony in the winning of all coal available, and protection against accidents.

In the case of Samson's colliery, the railway passes over an area of partially-wrought ground, the coal being at a depth of about 126 feet below the surface.

To this point it is necessary to draw the attention of the Government, in case of future mishap to the line, owing to the settling down of the formation when the coal is worked out.

The thickness of the seam throughout this district is about 18 feet, but, owing to the soft nature of the roof and floor, it has been the practice to work only six feet out of the centre of the seam. This is doubtless an extravagant system, as two-thirds of the coal has to be left; but it seems probable that it is the one which is best adapted for the district, as any other system would require extensive timbering—an item of no small cost in Otago.

Otago Colliery.—The workings in this mine are irregular, but form a nearer approach to the "Room and Rance" system than any other. The workings are in a fair condition, with the exception of the return air course, which is reported as being in a dangerous state, in places being almost choked to the roof with the *debris*. The result of this is of course necessarily to render the ventilation of the mine very imperfect.

Freeman's Colliery.—This mine is worked on the "Room and Rance" system, rooms 14 feet to 18 feet wide being opened out on each side of a "dip" drive.

These workings are at present standing well, but as they are extended considerable waste may be looked for, as the nature of the roof and floor is such as not to warrant rooms of more than 12 feet in width being taken out in the first instance.

Samson's Colliery.—The workings in this mine are extremely regular, due attention being paid in driving the levels, headings, and rooms to keep the work as straight as possible, and the roadways are in all cases in thoroughly good working order. The ventilation in this mine is also satisfactory, and, generally speaking, the mine is worked on an efficient system.

Walton Park Colliery.—The "Room and Rance" system is employed here as in the other mines, and, although the workings are of considerable extent, and have been carried on without any working

plans, they are very regular throughout, and are in good order. The roadways are in good repair, and the ventilation perfectly satisfactory, greatly to the credit of the underground manager, who has necessarily been working under disadvantages.

Saddle Hill Colliery.—This coal is wrought on the "Room and Rance" system, the rooms, which are 14 feet wide, being driven at an angle to the strike of the coal, and thus serving the place of headings. An easy gradient for trucking the coal to the level is also obtained by this means. The present workings of the mine are in good order, and the ventilation is good.

In the Green Island district it seems probable that an area of about eight square miles may be reckoned upon in which coal of a workable quality will be found, from which, on the present system of working six feet only from the centre of the seam would give a yield of about 28,000,000 tons of coal, about 46,500,000 tons being left unworked.

It will be seen by the table appended to Mr. Denniston's report that the average amount of coal won per man per day in the Green Island District is the least of any of the working collieries of New Zealand, and that the cost of getting the same is higher here than at any other mine.

The slack is in all cases, excepting the Walton Park Colliery, thrown to waste, and at that mine it is only utilized to a small extent in burning bricks, being mixed with the clay.

This system assists in the burning of the bricks, and is a simple way of utilizing what would otherwise be thrown to waste.

The mines, however, may be considered as very expensively worked, and, as the coal is of an inferior quality, they cannot be expected to compete with the more valuable deposits of that mineral in other localities.

Kaitangata Mine.—This is the third mine which has been opened in this important coal field, which extends over 40 square miles, and is estimated to contain 100,000,000 tons of coal.

The first mine opened was in an inconvenient position on the sea coast, and the second was only in a subordinate seam about half a mile from the present mine.

The new mine is opened in a seam 27 feet in thickness, dipping at 1 in 16 under the flat on which the Kaitangata Township stands, and rising into the hills which form the coast range. It is worked on an irregular system of Post and Stall, the pillars being about 16 feet square.

The workings of this mine, which have not been long opened, are hardly an acre in extent, the length of the main drive being 180 yards, of which 110 yards are in coal.

In the lower part of the seam the coal is of superior quality, having a hard splintery fracture, laminated structure, and the joints being enfilmed with pyrites, or brass of the miners, which is rarely seen in brown coals.

The quantity of coal already mined is stated at 10,000 tons, 17 miners being employed in April last.

The cost of mining and hauling is 3s. 9d., the freight to Dunedin 8s., and royalty 1s. per ton; but there is a heavy charge for interest on the capital sunk in a branch railway and other preliminary works, so that the coal is delivered in Dunedin at 22s. per ton.

General Remarks.

The present knowledge concerning the coal fields of New Zealand proves that good workable seams of coal occur at all the localities where mines have been opened up, and that a great extent of coal measures yet exist, which have never, up to the present time, had any work expended upon them. There is no doubt that in the future these deposits of coal will prove of great value to the colony, but the work which has already been undertaken shows how necessary it is that all mines which are opened up should be placed under the direct supervision of Government, to insure proper attention being paid to the ultimate safety of the mines and the maximum yield of coal.

James Hector, Director.

GEOLOGICAL REPORTS.

REPORT ON THE GEOLOGY OF THE MOUNT SOMERS DISTRICT.

BY S. HERBERT COX, F.C.S., F.G.S.,
Assistant Geologist.

6th November, 1876.

Instructions to Mr. Cox by Dr. Hector.

I WISH you to take next steamer to Lyttelton, and proceed to Mount Somers district, for the purpose of obtaining a suite of the quartziferous porphyries and other rocks of the district. Also, to revise the arrangement of the strata as shown in Dr. Haast's Geological Map, in accordance with our later knowledge, as shown in the appended schedule, in which I have shown the probable equivalents of Dr. Haast's classification.

This work will occupy about a fortnight, but if anything occurs during your explorations to make it desirable to occupy longer in the district, you will inform me. Also report progress on every opportunity.

SCHEDULE OF FORMATIONS.

Pleistocene.	
Pliocene...	Old plain deposits. Awatere = Wanganui. Kanieri = Taipos.
Eocene ...	... (1.) Mount Brown calcareous sands, with *Echinoderms*, etc.
Lower *Eocene* and Chalk.	(2.) *Grey Marls*— *a.* Clay beds. *b.* Calcareous green sands (Weka Pass stone). (3.) *Chalk Marls*— *a.* Tuff and limestone breccia. *b.* Amuri limestone. *c.* *Leda* marls.
Lower Chalk	(4.) *Green Sands*— *a.* *Teredo* limestone. *b.* Dark green sands. *c.* Saurian beds. (5.) *Amuri Series*— *a.* Black grit. *b.* Sulphur sands. *c.* *Belemnite* beds and calcareous conglomerate.

(6.) Great porphyritic conglomerate (Mount Somers volcanic series), acidic trachyte.
(7.) Green sandstone and slates (Mataura series).
(8.) Putataka beds.
(9.) *Wairoa Beds*—
a. Upper *Halobia* beds.
b. Lower Nugget Point beds.
(10.) *Maitai Formation*—
a. Silky slates (gold).
b. Cherty slates.
(11.) *Mount Arthur Series*—
a. Reefton beds.
b. Batten River.

REFERENCES TO DR. HAAST'S MAP.

1, 2, 3, 4 } Correct.
5 May be either No. 1 or No. 2*b*.
6 = 3*a*.
7 = 4*b*.
8 = No. 1 or No. 2*b*.
9 = 5*c*.
10 = 6.
11 = 6.
12 = 6.
13 = 6.
14 = 6.
15 = 5*c* or 6.
16 = 5*c*.
17 = 6.
18 = 6 or 7.
19 = 6 or 7.
20 = 7.
21 =
22 = 8.

5th December, 1876.

I HAVE the honour to inform you that, in accordance with your instructions, dated 6th November, 1876, herewith appended, I left Wellington on 7th November, arriving at Mount Somers on the 13th, and from that date, until 28th November, I spent my time in examining the sections in the district, correlating these, as described by Dr. Von Haast, with our latest classification, and making collections of the volcanic and other rocks of the district. I returned to Wellington on 1st December.

The following notes embrace the results arrived at during my trip:—

I have not seen occasion to alter in any way Dr. Von Haast's map of the district, as published in the Geological Reports for 1872–73, nor, indeed, so far as the slates, sandstones, and conglomerates of the Clint Hill series are concerned, have I been able to obtain sufficient *data* to fix definitely their horizon.

The mapping of this district by Dr. Haast has been most accurate,

and he must have devoted a great deal of time to the study of the rocks. I shall in this report simply make brief mention of the various formations, more especially referring to the calcareous and green sand beds, and their probable relations to the coals.

Clint Hill Series.

The beds of the Clint Hill series consist of alternations of grey and green slates, interstratified with certain deep red-coloured slates. These pass, in their lower beds, into a green sandstone, with many indistinct plant remains, or carbonaceous markings, below which are thick beds of conglomerates and sandstones, also with plant remains, from which Dr. Haast has recognised several species (see report on Clint Hills, Geological Explorations, 1872–73).

I should be inclined to place these beds as the equivalents of the Mataura series, but the time I was able to devote to the district was quite inadequate for anything like a perfect study of these rocks.

The strike of these beds is nearly north and south, and from the River Stour they dip to the westward, under the main range of the Clint Hills.

Melaphyre Formation.

Resting unconformably upon the denuded and upturned edges of these beds the melaphyre formation is seen. This formation consists of beds of tufa, which, at certain points, are interposed between the slates and sandstones previously mentioned and the lowest solid melaphyre flow, of which there appear to have been several. Beds of tufa have been formed over certain parts of this area contemporaneously with the eruptions during which the melaphyre streams were ejected, and are interstratified with the various streams of melaphyre before mentioned. These beds become highly vesicular at points, and assume an amygdaloidal structure, but, as a rule, the streams of melaphyre are close-grained, hard, and compact. They are found in the Gawler Downs, where subsequent disturbance has tilted them to a very high anglè, between Mount Somers and the Mount Winterslow Range, and also capping the Clint Hills to the south-east.

It is in connection with these rocks in the Gawler Downs that the palla occurs—a silicious rock, very variously coloured in shades of pink and green, and associated more or less with tufaceous beds. It is cropping out at points on a spur immediately at the back of Mr. Peter's station, and is, I believe, the deposit of thermal springs, or, at any rate, owes its origin to hot water in some way or other.

Trachytic Series.

Overlying these basic volcanic rocks comes an acidic series, consisting of tufas and many alternations of quartziferous porphyries and pitch-stones, varying considerably in colour, and containing small crystals of garnets and quartz.

I shall not make further mention of these volcanic rocks as regards them specially, since Dr. Haast has devoted considerable space in his report to a description of the same, but shall have occasion to mention them once or twice in reference to the coal-bearing beds of this district.

Coal Series.

These beds require special notice, as certain highly interesting points occur in connection with them.

Before proceeding to particularise, I may firstly state that evidence appears to me to point to the occurrence of two coals, perfectly distinct as regards age. One of these is older than the acidic series of Mount Somers, and, consequently, as will be seen further on, older than the marine calcareous and green sand beds, which will be hereafter mentioned. The other is of much more recent origin, and lies in basins or hollows excavated in the above-named acidic series; and the absolute age of these coal beds we have no means of determining, as they do not appear to have any connection in this locality with any beds of less age than themselves. Dr. Von Haast has mentioned the occurrence of each of these coals, but does not seem, as far as I can understand him, to have been particularly struck with the difference between them. With reference to the older of these coal deposits, typical sections may be seen in Woolshed Creek, and also in Petrifying Gully.

The section in Petrifying Gully is as follows :—

(1.) Reposing upon the older sandstones and slates, beds of sand occur, varying much in character and colour—various shades of orange and salmon colour being seen. These are overlaid by about 8 feet of pure white sands.

(2.) Above these a thin seam of coal, a few inches thick, occurs.

(3.) Next in order, a band of sulphurous shales appear, which pass into clayey beds, with dicotyledonous leaves and indistinct impressions of plants.

(4.) Next comes the main seam of coal, about 10 feet thick, (including certain shaly beds interstratified with it), very inferior in character.

(5.) This coal is overlaid by tufaceous beds, which pass, in a very short distance, into a coarse volcanic breccia, composed chiefly of angular pieces of pitchstone and porphyry of very various sizes.

(6.) From here, until passing the summit of the Cox Hills, no outcrops are to be seen; but in the bight between them and Mount Somers quartziferous porphyries appear, evidently overlying the breccia before mentioned; and upon certain tufaceous, or highly decomposed beds of these porphyries, which may be of value for the manufacture of kaolin, come the higher coal measures to be presently described.

The dip of these beds is N. 50° W., at an angle of 40°.

The section in Woolshed Creek is similar to the above, the coal undoubtedly being overlaid by pitchstones and quartziferous porphyries.

Dr. Haast describes a section (page 13, Geological Explorations, 1872–73) in the vicinity of the Clint Hill Station, in which the coal is also associated with beds of sand, the lowest beds of which, as in Petrifying Gully, being highly ferruginous; and these beds also rest upon the older slates and sandstones. They are not, however, overlaid by volcanic rocks at this point, but by further deposits of quartzose sands, which may possibly account for an apparent discrepancy which occurs in the section between The Brothers and Limestone Bluff, which will be described in the course of this report, and where the trachytic series are *overlaid* by light-coloured sands.

Whether these beds belong to the older coal series or not is at present an open question, but I shall further on adduce what proofs I can concerning them.

Now, referring to the upper series of coal-bearing beds. These may as well be described here as at any other point, no *datâ* being to hand wherewith to fix their proper horizon.

These beds, as before mentioned, lie in the hollows of, but apparently perfectly conformable with, the acidic series. They occur in the bight between Mount Somers and the Cox Hills; in Coal Creek, a branch of the River Stour; and in Alexander Creek.

The coal of Coal Creek is the only deposit which, up to the present time, has been worked, and this has only a local value. The seam here is about 14 feet thick, and was formerly worked by a drive, which has, however, been recently abandoned, and allowed to fall in, and the coal is now being stripped, a thin covering only appearing above it at this point.

Below the coal, shales appear, which, in turn, rest upon porphyritic tufas, highly decomposed, of varying shades of yellow and white, and these pass down into regular quartziferous porphyries.

In Alexander Creek, thin seams of coal occur, interstratified with shales, and resting upon quartzose porphyries. In the bight between Mount Somers and the Cox Hills similar sections may be seen.

Reposing, to all appearance perfectly conformably, upon certain highly decomposed tufas—which would very probably prove of value for the manufacture of kaolin—come a series of clays, marls, and shales (unfossiliferous), with bands of brown coal, the greatest thickness of any of which is about 5 feet 6 inches. Interstratified with these are beds of highly pyritous sandstone, and also thin beds of clay ironstone. The coal in this locality is generally very inferior, the woody structure being apparent; and, indeed, in many cases, the wood appearing to have scarcely undergone any change beyond having to a greater or less degree become carbonised.

It will be observed that I mention these coal beds as apparently conformable with the tufaceous deposits which immediately underlie them, but, at the same time, I think it highly improbable that such a conformity exists in reality. As before mentioned, they occur in the hollows of the trachytes, and, in the case of Coal Creek, the quartziferous porphyries rise abruptly at a short distance behind them, so that, I think, there is little doubt that the appearance of conformity in the beds themselves is deceptive, and that no such conformity really does exist.

Calcareous and Green Sand Beds.

The following section of these beds may be observed between Limestone Bluff, on the Ashburton, and The Brothers, the whole development, as here shown, lying between the southern branch of the Ashburton and the Northern Hinds.

Section from Limestone Bluff to Brothers.

(1.) Flaggy limestone.
(2.) Compact limestone (Mount Somers building stone).
(3.) Palagonite tufa.
(4.) Green sands (with included fragments of vesicular lava).
(5.) Marly limestones (with *Echinoderms*).
(6.) About *100 feet* (not seen).
(7.) Shell limestone and calcareous grit (with numerous casts of shells).

(8.) Glass-making sands, coloured with light hues.

(9.) Quartziferous porphyries.

The above may be taken as the typical section of the district, and it comprises by far the greatest development of rocks of any section thereabouts.

At the Limestone Bluff, a complete section may be traced from the lowest beds seen, viz., the quartzose sands, which rest unconformably upon the quartiferous porphyries, up to the flaggy and coralline limestones, which form the highest member of the series.

Between the Limestone Bluff and the outlier of the slates, which appears between this point and The Brothers, a syncline occurs, and on the eastern side of this syncline the lower beds are wanting, the green sands and palagonite tufas resting unconformably upon the slates and sandstones before mentioned, while on the other side of these slates and sandstones no beds appear, save the palagonite tufas, which are there in considerable mass, and represent a solid flow. This want of the lower beds on one side of the syncline might be taken as strong evidence in favour of an unconformity existing between the palagonite tufas and upper beds, and the underlying limestones and sandstones, and it will be seen that I am inclined to favour this view, notwithstanding an apparent stratigraphical conformity throughout on the western wing of the syncline. However this may be, I simply quote the facts as they occur, and prefer to leave the inferences to be drawn from them more or less open at present.

A similar section to that at Limestone Bluff, the western wing of the syncline, may be seen in Chapman's Gully, with the exception that no beds below the marly limestones (No. 5) are seen, the sequence above these being precisely the same as at the Limestone Bluff.

At the back of the Mount Somers' Station, and also at the Somers' Caves, the section is only complete as far as can be seen, from the flaggy and coralline limestone, forming the highest beds of the series, to the upper surface of the palagonite tufas, which are here much decomposed, but not so much as to leave the least doubt of their identity with those which occur at The Brothers, and in other parts of the section, which I have given in detail.

With reference to the age of these beds, two solutions may be given, depending upon the question of unconformity before cited whether one or the other be correct.

In the first instance, I will give a description of the beds in question,

and afterwards show what evidence can be brought in favour of either conclusion.

The limestones, both flaggy and coralline, and also the compact limestone, which forms a most excellent building stone, distinctly belong to the same formation. They contain *Pecten hochstetteri*, *Waldheimia lenticularis*, *Terebratula*, *Terebratella*, etc.

These beds become glauconitic in their lower beds, and then pass into green sands, interstratified with palagonite tufas. It is at the point where these calcareous beds first become glauconitic, and from there, until their passage into the green sands, that the principal fossil collections are to be made, and from them I obtained *Pecten athleta*, amongst other forms. These pass down into marly limestones, with *Echinoderms*, and from there the section is obscured until the point where the calcareous grit crops out is reached, below which the glass-making sands appear, resting unconformably upon trachyte porphyries.

Stratigraphically speaking, a perfect conformity exists between these beds from the highest to the lowest member of the group, where they are all seen together, and the evidence of unconformity rests on the absence of the lower members of the group on the eastern wing of the syncline, between Limestone Bluff and The Brothers.

Now, considering that the absence of the lower beds on eastern side of the syncline does not indicate an unconformity, but simply the thinning out of the beds towards that point, their place being taken by a greater thickness of the submarine volcanic flow. If this be the case, we have to consider that the flaggy and compact limestones, Nos. 1 and 2, which are the highest beds seen, are the equivalents of the Otatara limestone; then beds Nos. 3, 4, and 5 would be the equivalents of the Amuri limestones and *Leda* marls, having their counterparts in submarine volcanic rocks, which occupy a similar position at Waiareka Valley, Oamaru; Nos. 6 and 7 would represent the concretionary green sands and Saurian beds of the Amuri Bluff section, and No. 8 the upper part of the coal series.

This arrangement would correspond with sections which have been obtained in other parts of the colony, but has the difficulty in the way that the before-mentioned evidence of unconformity would have to be totally disregarded, and, at the same time, brings the upper limestone to a lower horizon, that I am inclined to give it from the evidence of the fossils.

Now, if the other solution be taken, we get the following arrangement:—The upper limestone, Nos. 1 and 2, would represent the Mount Brown limestone; Nos. 3 and 4 would then have their equivalents in certain land areas of volcanic rocks, which occur at that horizon at Oamaru, and below this point a palæontological break would occur, and the sequence from these down would be the same as in the former case.

I am strongly inclined in favour of this last case, both on stratigraphical grounds and also in view of the fossils obtained from the higher beds.

The question yet remains, however, can these beds of the Amuri series have so contracted at this point as to descend from a total thickness at Amuri Bluff of not less than 1976 feet to a thickness here of certainly not more than 400 feet? The evidence gained by Mr. McKay in his Canterbury and Otago trip of this year, clearly shows that the grey marls are much contracted down south, and, I believe, it will be found that this section at the Limestone Bluff represents the entire sequence of the *Eocene* and chalk beds.

Now, in reference to the age of the coal, no evidence, as far as fossils are concerned, can be furnished; and all we can do is to adhere to stratigraphical evidence.

It will be remembered that the older coals underlie the trachytic rocks of Mount Somers, and it will be seen that these trachytes are themselves overlaid by the marine beds in the section described between The Brothers and Limestone Bluff. These coals, then, are of greater age than any of the marine beds which have been seen in the locality, but the occurrence of this trachytic series between them and the lowest marine beds makes it impossible at this point to say what may be the absolute relations between them, but I see no reason to doubt that the lower coal-bearing beds here are the true coal measures of New Zealand.

With reference to the upper coal measures, I am unable to furnish any *data* whatsoever for the determination of their age.

In conclusion, I would remark that there seems every reason to believe that in course of time the Mount Somers district will be one of considerable value. In the locality, and within an area of a very few square miles, limestone occurs, forming an excellent building stone; extensive deposits of sands, of high value for glass-making purposes are

found; ironstone occurs in the district; and further, the decomposition of the quartziferous porphyries has, at many places, been the agent in the formation of kaolin, which will at some time or other be used for the manufacture of porcelain.

REPORT ON WAIKATO DISTRICT.

BY S. HERBERT COX., F.C.S., F.G.S.,
Assistant Geologist.

To accompany Map and Sections.

Instructions from Dr. Hector.

9th December, 1876.

You will take the steamer for Auckland on Tuesday next, and proceed thence to the Waikato Heads, where you will examine and collect largely from the *Belemnite* and plant beds, and establish definitely their relation to one another, and also the relations of the plant beds to the younger coal-bearing rocks.

Follow the coast section from there to Raglan, going inland until reaching the basaltic plateau of the interior.

Try and visit Kawhia, and collect fossils, noting the section along south side of harbour from Albatross Head.

From Raglan cross the Hakarimata Range to Whata Whata; examine the fossiliferous beds with *Monotis*, on the western side of the range, and see whether they do not form an unconformable syncline of moderate extent, as at Wairoa; and also try and see reported coal deposits in the same direction.

Examine carefully the section of the eastern side of the Hakarimata Range at Whata Whata, and endeavour to find out the relations between the coals and overlying marls, sandstones, and limestones.

Pass on to Kupa Kupa, and trace carefully the boundaries of the coal formation here, thence on to Drury and Auckland.

Take steamer to Wangarei, where carefully note the relations of the coal-bearing beds to the older rocks, and to the fossiliferous sandstones of Tiger Hill. Trace the extent of the coal in this locality as far as practicable, reporting on what has been done, as there has been some Government expense incurred there.

The object throughout this trip is to be the collection of accurate geological *data*, more especially referring to the extent and age of the coal-bearing beds; and good fossil and rock collections are to be made in all localities where practicable.

If there is time, the beds between the Auckland Harbour and Kaipara require examination.

Mr. Denniston, who is placed under your orders, is engaged for not more than six months, dating from November 20th.

You will employ him as much as possible in tracing coal boundaries, so as to leave your own time free for the elucidation of the geology of the district.

You will be furnished with sketch maps, showing what is known of the district, and further instructions may be forwarded to you from time to time.

1st February, 1877.

I HAVE the honour, in pursuance of your instructions, dated 9th December, 1876, to make the following report on the geological formation of the Waikato district.

I left Wellington on the 13th December, and arrived in Auckland on the 16th, proceeding to Mercer the same day. On the 21st, I took the steamer to the Waikato Heads, having devoted the intermediate time to an examination of the beds round Mercer.

From 21st December, 1876, to 1st January, 1877, I remained at the Waikato Heads, working out the geology of the so-called Putataka beds, and also of the younger limestones and marls along the coast, as far as Huriwai.

On the 5th January, I arrived at Raglan, having examined the coast section between there and the Waikato Heads. On the 6th, I proceeded to the Waitetuna, where I remained until the 9th, examining the secondary beds there, and also the coal formation which caps the Kapamahunga Range.

On the 10th, I reached Whata Whata, where I remained until the 16th, examining the extension of the coal measures and overlying marls and limestones. On the 16th, I reached Ngaruawahia, examined the slates there, and then proceeded to Kupa Kupa, where I examined Ralph's Mine, which had been opened since I was here last; and, leaving the more detailed work of mapping the coal boundaries for Mr. Denniston, I proceeded, arriving at Mercer late on the 20th.

On 22nd January, I took the train to Auckland, and steamer thence to Riverhead, between which place and the Kaipara Harbour I remained until the 26th, when I returned to Auckland, and thence to Wellington, Mr. Denniston not being yet ready to proceed to Wangarei. My explorations during this trip have tended to throw light upon the following points :—

1stly. The age of the fossiliferous beds of the Waikato Heads, their relations to the plant beds, and also to beds at other parts of the colony.

2ndly. The relations between the coal beds and the overlying calcareous beds.

3rdly. The positions and character of various marly and sandy beds, which have been hitherto grouped under the title of Waitemata beds, but which I find it necessary to subdivide.

The beds which have been examined during my present trip I propose to subdivide in the following manner, adhering, as nearly as possible, to the names which have been previously given them here, but adopting, at the same time, the classification which has latterly been adopted generally for the New Zealand beds :—

Pleistocene	...	Blown sands.		
		Pumice terraces.		
		Boulder formation.		
		Plastic clays and sands.		
Eocene ...	...	Kawhia limestone.		
		Aotea sandstone.		
		Blue clay marls.		
Cretaceo-tertiary ...		Grey marls	...	Clay marls.
				Sandy marls and calcareous sandstone.
		Chalk marls	...	Flaggy limestone.
				Calcareous green sands.
				Brown sands and marls.
				Mercer beds.
				Leda marls.
Lower green sand...		Coal measures.		
Jurassic ...	...	Mataura series	=	Putataka plant beds.
		Putataka series	=	*Aucella* beds.
		Wairoa series	=	*Monotis* beds.
Palæozoic	...	Maitai series	...	Rimutaka slates.

Before proceeding to a specific description of these beds, I shall first mention the localities in which they occur, and under what conditions, reserving a special account of their properties and relations for the present.

It will be seen on reference to the map that a belt of slates run through the country, from the Frith of the Thames to Ngaruawahia, and appears also in the Kapamahunga Range, further south, towards Whata Whata, but here it is overlaid on the east side by the coal measures and chalk marl formation, which rise to an elevation of 650 feet above the level of the sea; the highest point of the range here being about 840 feet.

These beds (the slates) are the oldest seen in the district under consideration. They appear to belong to the slate series of the Thames gold field, and are probably the equivalents of the Wellington slates. Their strike, opposite Whata Whata, is N.N.E., and their dip W.N.W., at an angle of 60°, while at Ngaruawahia they appear to be striking E. — W., and dipping south, at an angle of 60°; but the observations here are scarcely reliable owing to the character of the beds.

Reposing unconformably upon these beds, on the western side of the range, a series of fine micaceous sandstones, hard slaty sandstones, and dark-coloured marlstones, with dark blue calcareous concretions occur.

The strike of these beds, as exposed on the western flanks of the Kapamahunga Range, is N.N.W., with a westerly dip, averaging about 45°, and at the Waikato Heads, where the marlstones again make their appearance, as shown on the map, they form the centre core of an anticline, with a north-west and south-east axis, and they are here overlaid by a series of sandstones, marlstones, and slates, with plant remains, which again make their appearance between the Waikato Heads and Raglan, as an outlying patch at Otahe Point.

Between the Waikato Heads and the Kapamahunga Range a belt of country exists over which these older fossiliferous beds do not appear at the surface, and this area is occupied by the coal measures and younger beds, which rests unconformably upon the plant beds, marlstone, and slates, indiscriminately, the coal measures themselves appearing to occupy the south-east side of the basin; flanking the slate range to the north-west, from the Mangaohei Stream to the Miranda Redoubt, and also appearing at places, as opposite Whata Whata, and near Taupiri, on the south-east side of the range.

Immediately above the coal measures, and overlying them comformably, the *Leda* marls appear, these beds having their typical development at the Wangape Lake, but also appearing in the Waitetuna arm of the Raglan Harbour, and on the North Shore, opposite Raglan. They also occur above the coal, between Whata Whata and Ngaruawahia, near Rangiriri, on the banks of the Waikato; above the coal seam at Foote's Mine, Miranda Redoubt; between the Maungatawhiri Creek, Mercer, and the Queen's Redoubt, and at one or two places below Mercer, on the banks of the Waikato.

They are overlaid in the Waikato Basin by a series of light blue marls and loose brown sands, in which fossils are very scarce, but which

appear to be the equivalents of the Waitemata beds, as developed towards Riverhead, in the Auckland Harbour.

These beds are well exposed in the railway cuttings near Mercer, and they are also seen at Foote's coal mine, in both cases the *Leda* marls appearing at the base of the series, and they must, I am inclined to think, be considered as the higher beds of the *Leda* marls, as developed towards the centre of the basin.

In the Raglan Harbour the *Leda* marls are overlaid by calcareous green sands with, at points, a decided band of green sand intervening, and these pass up into a flaggy limestone, which I consider to be the equivalents of the Amuri limestone; the calcareous green sand representing the fucoidal limestone, which occurs in the same locality. At the back of the Wangape Lake, the marls pass into a more flaggy character, and strongly resemble the Cobden limestone, being overlaid by a calcareous sandstone, which forms the base of the grey marls.

Between Raglan and the Waikato Heads the *Leda* marls do not make their appearance. The lowest beds seen of the calcareous series being the calcareous green sand, which makes its appearance at several points, as at Huriwai, Waikawau, Otehe Point, and Karakerau, but in each of these cases is overlying the Putataka plant beds unconformably; and all intermediate beds, including the *Leda* marls and the coal, are wanting in this district.

Between Whata Whata and the summit of the Kapamahunga Range, the limestones again appear overlying the coal, a belt of marls (*Leda* marls) intervening between the two.

Overlying the flaggy limestone comes another series of marls and sandstones of somewhat various character.

At points in the Raglan Harbour they are sandy clay marls, and north of Te Hara Point, until reaching the Waikato Heads, they become hard calcareous sandy marls, which at places merit the name of sandstones, as which they have been described by Captain Hutton (Geological Explorations, 1867).

Its position, however, and general characters are identical with the so-called grey marls of the Amuri Bluff, and as this is now our typical section, I propose to adhere to the names adopted for these beds in that locality.

At Waikawau, above the grey marls, and, as far as stratigraphical evidence can show, comformable with them, a development of light blue marls, with a dark green sandish bed at their base, containing a large number of fossils, are seen, and these beds are overlaid by sandstones,

which are also fossiliferous. Captain Hutton described these as the Waitemata beds (Geological Explorations, 1867), and placed them provisionally as the equivalents of those developed at Mercer, but this position will now be quite untenable, as their stratigraphical position will show in the first instance, and their fossil contents places the matter beyond a doubt.

These blue marls, which it has been decided to call the *Cardita* beds, would appear to represent the lowest *Eoeene* beds of New Zealand, being overlaid conformably by sandstones and limestones, which have their decided equivalents in those beds known as the Mount Brown limestones; and, although I am unable to say that any unconformity exists between the *Cardita* beds and the underlying grey marls at this point, I still think that evidence gained in other parts of the colony places this horizon as the point at which such an unconformity does occur, although no additional evidence in favour of this view can be gathered from the sections here exposed.

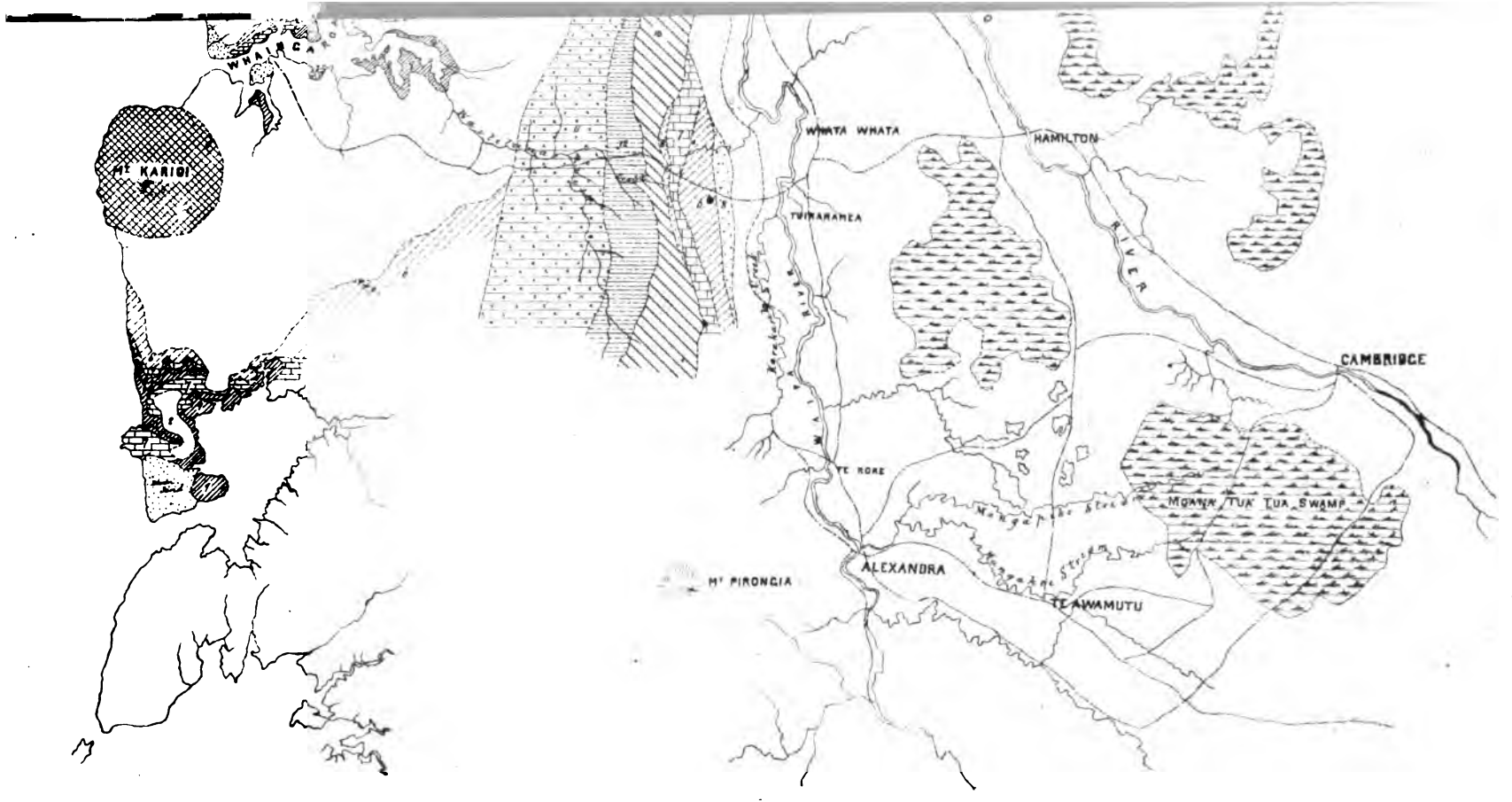
These beds appear also at Te Hara Point, where the clay marls of this series are overlaid by a grey sandstone, weathering brown, to which Captain Hutton has also applied the name of Aotea sandstone in his report on this district. This name I propose to retain for the present; firstly, because these sandstones are represented in the vicinity of Aotea; and, secondly, because in my report on the Raglan district, in 1874, I then adhered to the name, and the lists of fossils from there were given under that title.

Subsequent explorations show these, with certain limestones which overlie them, to be the probable equivalents of the Mount Brown limestones of the South Island, or, in all probability, of lower *Eocene* age.

This limestone, known as the Kawhia limestone, is also better seen at Te Hara Point than elsewhere, but it also occurs at the back of the Wahi Lake, at the head of the Mangaohei Stream, where it is the highest bed seen above the grey marls and calcareous sandstones; the intermediate beds above mentioned either being wanting, or, at any rate, not appearing at the surface.

I mentioned this limestone in my report (1874) as the Kawhia limestone, in deference to Captain Hutton's naming, and, although I have not myself seen the limestone at Kawhia, and think it doubtful whether Dr. Hochstetter meant this limestone when he first gave the name, I propose to keep it in this report to avoid confusion.

Above this point a decided stratigraphical break occurs, and the


WHAIRCA
Mt KARIOI
WHATA WHATA
HAMILTON
TWIRAMEA
RIVER
CAMBRIDGE
TE ROKE
MOANA TUA TUA SWAMP
ALEXANDRA
Mt PIRONGIA
TE AWAMUTU

SECTIONS
RAGLAN AND WAIKATO

SECTION - WHATA-WHATA TO RAGLAN

SECTION - WAIKATO HEADS

SECTION - POKENO TO WHANGAMARINO CREEK

COAST SECTION - KORUHINE

COAST SECTION - WAIKATO HEADS

COAST SECTION - OTAHE POINT

COAST SECTION - WAIKAHAU CREEK

SECTION AT HURIWAI CREEK

SECTION - TE HARA POINT TO RAGLAN

1a. BLOWN SAND
1c. BASALTIC TUFFS AND IRONSANDS
1c' BASALTIC LAVAS
5a. KAWHIA LIMESTONE
5c. MOTEA (BROWN) SANDSTONE
6a'. CARDITA BEDS
6a. GREY MARLS
6c. CALCAREOUS SANDSTONE
6d. FLAGGY LIMESTONE
6a" BROWN SANDS (MERCER) AND CALCAREOUS GREENSAND
6e' LIGHT BLUE MARLS (MERCER)
6e. LEDA MARLS
6m MATAURA PLANT BEDS
6h PUTATAHA BEDS
M. AMURIRA SLATES

Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S., DIRECTOR.

To illustrate Report by S. Herbert Cox, F.G.S., Assistant Geologist. February 1, 1877.

next beds seen are of pleistocene age. The lowest of these are the "plastic clays and sands" of Dr. Hochstetter. They contain bands of impure lignite at places, and are overlaid by the volcanic beds of the basaltic boulder formation, which covers so great an area in this district.

Under the volcanic formation must be included the pumice sands and alluvial deposits of the Waipa and Waikato Rivers, and of lakes which formerly existed at many places in the Waikato Basin; the lava streams of Karioi, Pukekawa, and other smaller volcanoes; the ironsand deposits and overlying ferruginous and quartzose sands, and the tufaceous beds, the whole of which will at some future time require careful attention, when a thorough mapping of the country is taken up. In the meantime, I have grouped them together, finding it quite impossible to make any distinctions between them of a character that would have any practical value.

Finally, the blown sands of the coast occur at the mouths of all the West Coast harbours and rivers of any size, and encroach considerably at times on the coast land. The reclamation of land thus rendered waste is a matter of some interest to settlers.

As regards the boundaries of the foregoing formations, strict accuracy is not claimed, but, as far as I have been able, I have mapped these, and I think they will be found to be moderately correct, indeed, as near as could be expected, with small scale maps and no absolute points of reference to fix localities with.

I have visited personally most of the localities mentioned, but in a few cases I have shown in the boundaries of the formations from Mr. Denniston's observations, and with the aid of collections made by him.

Now, to refer to these formations in detail:—

I. Palæozoic Slates.

These beds are highly pyritous in character, as developed at Ngaruawahia, Taupiri, and towards the Thames.

It will be remembered that in my report on the "Raglan and Waikato districts" (Geological Explorations, 1874-75), that I mentioned the occurrence of *Monotis* in these beds, but a more careful examination of the country during my present trip has shown me that the beds from which I obtained the *Monotis* were not the same as the older slates of Ngaruawahia, but overlie them unconformably, and probably belong to a sequence of rocks, the occurrence of which in the Raglan district I was at that time disposed to question, viz., Hochstetter's lower Jurassic series. A full description of these beds will be given further on.

No fossils have, up to the present time, been discovered in the slates themselves, and it is much to be regretted that on that account we are still unable to specify their age with precision.

Lower Secondary.

These beds require subdivision into at least three heads. They are, to all appearance, conformable amongst themselves, but rest unconformably upon the palæozoic slates previously mentioned.

I propose to subdivide them as follows :—

1. Mataura slates and sandstones. } Plant beds.
2. Putataka beds, marlstones. } *Aucella plicata*, and *Inoceramus* beds.
3. Decomposing micaceous sandstones and hard blue sandstones. } *Monotis* beds.

These great divisions will require to be further subdivided in describing their characters, and also in the sections appended to this report, a reference to which will show the grounds upon which I have grouped all these together.

Referring to section No. 1, between the River Waipa and Raglan, it will be seen that upon the palæozoic slates, which rise to form the main range of hills, rest the micaceous sandstones above referred to.

The strike of the slates at this point is N.N.E., and their dip W.N.W., at an angle of 60°, while the strike of the fossiliferous sandstones is N.N.W., and the dip westerly, at an angle of 45°.

It is on these grounds that I show an unconformity as existing between the two series here, as no direct junction could be seen, as far as I was able to make out, although I traversed a creek (a branch of the Waitetuna) until reaching the coal measures on the south-eastern side of the range.

In the micaceous sandstone fossils are very plentiful, but appear to be exclusively confined to the genus *Monotis*. They are the equivalents of the Wairoa beds of Nelson, classed as Triassic by Dr. Hochstetter.

Above them come certain hard blue sandstones, in which fossils appear, but they are by no means numerous, and the matrix is so hard as to render collecting with a hammer almost impossible—they, however, contain *Halobia*, *Astarte*, etc.

They pass up into marlstones, which, at this point, proved to be unfossiliferous in character, as far as I was able to ascertain, but they are so similar in character themselves, and contain calcareous concre-

tions, also so similar to beds which appear at the Waikato Heads, that I have no doubt that they are identical with them.

Higher than this in the sequence I have been unable to trace in section No. 1, as the higher portion of the beds where I went are obscured by the volcanic tufas of the basaltic boulder formation, and the *Leda* marls also shortly make their appearance after passing the point where the secondary beds are first lost.

The section is, however, again taken up at the Waikato Heads, where the lowest beds seen are the dark coloured marlstones, with calcareous concretions, as described above.

The beds at this point form an anticline, as shown in section No. 2, and the marlstones, which are here highly fossiliferous, form the centre core of this anticline, the axis of which runs about north-west.

From these beds I obtained the following fossils:—

Aucella plicata	*Belemnites aucklandicus*
Inoceramus haasti	*Halobia?*
Inoceramus (sp. ind.)	*Placunopsis striatula*,

and other species, which yet require working out and naming.

These beds become lighter coloured and more greasy in their higher beds, and very few fossils are to be seen in them near the highest point of their occurrence. They are at least 500 feet thick, and are overlaid by alternations of sandstones and sandy marls, with occasional slaty beds, in all of which are plant remains in a more or less perfect state of preservation, but in many cases these are very indistinct.

The beds which here preserve the ferns most perfectly are sandy marls, which occur not very far above the junction of the marls and sandstones, and from which previous collections have been figured and named. I was not very successful in collecting from these beds, and do not think I have any fresh species to add to those already known.

Section No. 3 gives the complete sequence of these beds, which is as follows:—

About 1000 feet thick.

1. Sandstone.
2. Belt of slate conglomerate.
3. Slate, interbedded with sandstone.
4. Hard grey sandstone.
5. Banded slates (plant beds).
6. Concretionary sandstone (50 feet thick).
7. Hard grey sandstone, with marly and slaty beds.
8. Sandy marls (plant beds).
9. Slates, with indistinct plants.
10. Marls, with bands of hard grey sandstone.

About 500 feet thick. } 11. Dark coloured fossiliferous marlstone.

Associated with these beds thin seams of coal occur, of no commercial value, being very impure, and never of more than a few inches in thickness.

Coal Measures.

Between the foregoing beds and the coal measures a considerable break occurs, the intermediate beds, represented elsewhere by the higher part of the Poverty Bay oil rock section and the lower beds of the Amuri series, being entirely wanting in this part of the country. The coal measures have a considerable development in the central part of the Waikato Basin, between the Miranda Redoubt and the head of the Mangaohei Creek, and extending towards Mercer and the back of the Wangape Lake. Mr. Denniston is reporting fully on these deposits, so that I shall only briefly call attention to the facts as relating to their conformity with the overlying *Leda* marls, and consequent probable great extension of coal in the Waikato Basin.

At Mr. Foote's Coal Mine the coal passes up into the *Leda* marls, and above these certain beds of soft brown sandstone occur, from which fossils have been obtained. At Coal Creek, a branch of the Waitetuna, a similar section may be seen, and the beds at the back of the Kupa Kupa Coal Mine also bear out this point. This, then, would give presumptive evidence that the coal might be looked for throughout the Waikato Basin, as the *Leda* marls appear at the surface in the very centre of this basin, viz., at Rangiriri, and also at Church-hill, and back to the Wangape Lake, but this is not all.

In Mr. Foote's main shaft, a seam of coal, no less than 54 feet thick, has been struck at a level of 66 feet below the surface of the swamp, dipping N.E., at an angle of 5°, or under the swamp; and it may certainly from this be argued that the coal will extend through the swamp area which occupies so great an extent in the Waikato Basin, and when supported by the occurrence at the surface at various points, as before mentioned, of the *Leda* marls, I have no doubt that the extension does exist.

Of course, the only way in which this matter can be set at rest is by boring; and a bore-hole put down, either at Mercer or Church-hill, would settle the question either for or against, and at a comparatively small cost. Whether this is a matter for private enterprise, or for the Government, is another question; but I certainly think such a bore-hole would

be of greater value in proving a large area of country than almost any other work which could be undertaken in the colony. I am of opinion that Church-hill would be the best point for boring.

At the head of a small creek, a branch of the Waitetuna River, which the track from Whata Whata to Raglan crosses, at the western foot of the Kapamahunga Range, an outcrop of coal occurs at an elevation of 550 feet above the level of the sea. This outcrop has been obscured by a fall of *débris*, so that I was unable to ascertain the thickness of the seam at this point. It is, however, in such an inaccessible position that, the quality of the coal being no better than what is obtained from the Waikato Basin, it is comparatively valueless at present, more especially for Raglan, as any coal which might be worked from this deposit would be more readily delivered on the banks of the Waipa than on the Raglan Harbour, and the demand for coal at Raglan would be quite insufficient to keep a mine in work by itself.

These coal measures, which occur at the above mentioned point, flank the Kapamahunga Range to the eastward very much, as shown by Dr. Hochstetter. They are dipping W.N.W., at an angle of 10°; and at this point a thickness of about 60 feet only of sandy beds exists between the coal and the slates in a bight, in which formation they are here occurring. They are overlaid by sandy marls, from which I did not obtain any fosils, but their stratigraphical position, viz., immediately below the flaggy limestone, which occurs about 100 feet above the coal here, seems to fix them as the *Leda* marls.

Another outcrop of coal occurs on the banks of the Waipa, near Alexandra, and below Karikariki Creek. On the same river the *Leda* marls may be seen cropping out, pointing to an extension of the coal measures to this point.

Leda Marls.

These beds take their type from the marls of Wangape Lake, and are characterised by their greasy character, and the occurrence in them of *Leda*, *Turbenolia*, *Pecten zittelli*, and *Nummulites*, probably *Pecten zittelli* may be looked upon as their characteristic fossil, as it does not appear to pass higher in the series than the top of these beds.

They occur overlying the coal directly at Foote's Mine, near the Miranda Redoubt, at which point but a small thickness of fire clays intervene between them and the coal. They are overlaid at this point by loose brown sands, with harder included sandstone concretions, and from these beds we obtained, in 1874, *Turbinolia*, *Nummulites*, and *Pecten zittelli*, the characteristic forms of the *Leda* marls.

These beds appear again crossing the main south road, between Mercer and the Queen's Redoubt, and here also they contain the characteristic fossils of the group.

The marls in which the characteristic fossils (*Pecten zittelli*, etc.) are found here are light coloured greasy marls, and they pass up into sandy marls, brown sands, another bed of marls, and then a further development of brown sands.

From these higher beds, during my trip in 1874, we obtained the following fossils :—

MERCER BEDS.

Shark's teeth	*Cristellaria haasti*
Leda	Coiled *Nummulites*
Echinoderm	*Pinna*
Nautilus	Oyster (small)
Foraminiferæ (Duncan's)	*Dentalium nanum ;*

and, there is no doubt that they are in this locality the higher member of the *Pecten zittelli* beds or *Leda* marls.

They have been classed as the Waitemata beds by Captain Hutton (Geological Explorations, 1867), and placed by him as pliocene only, in age ; but I think the fossils now found are quite sufficient to bring them down to the horizon of the higher beds of the *Leda* marls

The sections show the occurrence and sequence of these beds as developed in the vicinity of Mercer.

The *Leda* marls make their appearance again between Mercer and Rangiriri, on the banks of the Waikato, having the same characteristics here as elsewhere, and they are, of course, again seen at the Wangape Lake, their typical point of occurrence to the westward of which point they pass into certain calcareous marly beds, very similar in character to the Cobden limestone, and representing the flaggy limestone at this point ; while between Wangape Lake and Mercer certain of the higher beds above mentioned also occur.

In the Raglan Harbour they again make their appearance. They occur in the Waitetuna branch of the Raglan Harbour, where they are overlaid by the calcareous green sand and flaggy limestone with perfect conformity ; the higher sandy beds, however, as developed in the Waikato Basin, being absent, or, perhaps, more correctly, having their equivalents in the belt of limestone and calcareous green sand above mentioned.

These *Leda* marls occur again on the north side of the Raglan Harbour, where also they are overlaid by the calcareous green sand and

flaggy limestone; but at one point here a thin bed of pure green sand intervenes between these two sets of beds.

Limestone Beds.

Under this head is included the flaggy limestone, from which the principal fossils are net and branching corals, and their underlying beds the calcareous green sand, in which *Fucoid* impressions are sometimes very plentiful, and which are the equivalents of the *Fucoidal* limestones of the Amuri Bluff; the limestone at the back of Wangape Lake being also included in these.

These beds occur, as I had occasion to mention previously, overlying conformably the *Leda* marls, in the Raglan Harbour; and they are overlaid by another series of marls, which I shall have occasion to mention again further on.

Between Raglan and the Waikato Heads they again make their appearance at several points, having been faulted to the surface, as shown in the coast sections. They occur north of Te Hara Point, where they form a low reef running out to sea; at Otahe Point, where they repose unconformably upon an outlying patch of the plant beds; to the north of Waikawau, and more or less continuously along the coast line from there to the Huriwai Stream, where they are well seen as the calcareous green sand and *Fucoidal* limestone.

At the Waikato Heads certain calcareous green sands appear as a reef running out to sea, and these are also, in all probability, the equivalents of the above; the flaggy limestones being wanting at this point.

They again make their appearance above the coal measures to the westward of Whata Whata, where they are occurring at an elevation of 650 feet above the level of the sea; at the head of Coal Creek, a branch of the Waitetuna, at an elevation of 600 feet, where the Raglan track crosses the Kapamahunga Range; and at an elevation of 500 feet in the Tuneki Creek, opposite Whata Whata, at which point a lime kiln has been at work for some time past, but has now suspended operations. The dip of these beds is N.N.W., at an angle of 10°.

Grey Marls and Calcareous Sandstone.

These beds overlie the flaggy limestone in the Raglan Harbour, and at all places along the coast between Raglan and the Waikato Heads, where they occur without any break in the sequence.

In the Raglan Harbour they are grey sandy marls, which, with the

blue clay marls, Captain Hutton has given the name of Whangaroa clays. The blue clay marls, however, overlie these grey sandy marls, and pass up into the Aotea sandstone of Te Hara Point, to be hereafter mentioned. Further north, the beds which overlie the flaggy limestone are somewhat various in their character, being at times a hard grey clay marl, and at others becoming so sandy as to merit the name which has been applied to them by Captain Hutton, of the Aotea sandstone; and in the range which runs N.S., to the westward of the Wangape Lake, they assume the character of a calcareous sandstone, in their lower beds strongly resembling the Weka Pass stone in character. They are, however, so decidedly marls at places, and, even where sandy, possess the marly structure—with the exception of the last mentioned locality—in so marked a degree that I think the term grey marls, which has been applied to their probable equivalents at the Amuri Bluff, is quite applicable to the great extent of these beds in the district under examination. They are further developed in the district near Whata Whata, previously referred to, where they also occur above the limestone which overlies the coal, or in the same stratigraphical position which they occupy between Raglan and the Waikato Heads.

Blue Marls and Altered Sandstone.

A reference to the map and sections will show that these beds occupy a comparatively small surface area here, and that where seen they appear to overlie the grey marls with perfect conformity. They extend from Waikawau to Kawa, and consist of light blue marls, with a bed of green sand at their base, in both of which fossils are very plentiful.

They are overlaid by a belt of sandstone, which has been considerably altered, and in which fossils are also seen.

This sandstone is the probable equivalent of the Aotea sandstone, to be hereafter mentioned.

These beds will have to depend upon their fossil contents to fix their horizon, and as good collections have been made from them no doubt as to their age will ultimately exist, when a comparison of their fossils with those of other beds shall have been completed. At present they would seem to be the lower portion of the Mount Brown beds, or of the very lowest *Eocene* age.

Certain blue clay marls, between Raglan and Te Hara Point, also belong to these beds, as, although I am unable to show this by fossils, the stratigraphical evidence of their conformity with the overlying sand-

stones and limestones in each case is so strong as to leave no doubt in my mind that they are horizontal equivalents.

Aotea Sandstone.

At Te Hara Point a bed of sandstone occurs overlying the clay marls previously mentioned as occurring there, and forming the equivalents of the *Cardita* beds.

This is the point at which the sequence is best seen, although the Aotea sandstone may also be seen overlying the grey marls in the northern arm of the Raglan Harbour, between the Whangaroa and Waitetuna Rivers, where they sweep round to the water's edge.

They do not, as far as I am aware, extend further north than Te Hara Point, but with the limestones which overlie them occupy a small patch inland in this locality, being capped by the basaltic boulder formation, which here comes down to the coast line on the high ground. An outlier of the same beds occurs above the *Cardita* beds, or blue marls, at Waikawau.

Kawhia Limestone.

This limestone, which crops out on the sea coast at Te Hara Point, is much coarser than the flaggy limestone of the Raglan Harbour, and elsewhere. It contains a large number of fossils, collections from which are deposited in the Colonial Museum for reference. It also occurs in a similar position at Waikawau, having, however, at this point become much coarser, indeed, quite conglomeratic. It is, however, I am inclined to think, of the same age as these beds. It contains *Pecten hutchinsoni* amongst other forms.

From the coal measures to this point no stratigraphical break would appear to occur in the sequence of the beds. They all pass one into the other in an invariable order, and with perfect apparent conformity; but on the western part of the area examined, viz., along the coast, the lower beds, the coal measures, and overlying *Leda* marls are generally wanting, appearing to have thinned out before reaching this point.

In addition to this, it appears highly probable, from work which has been carried on in other parts of the colony, that an unconformity exists between the grey marls and overlying *Cardita* beds, and, although this break cannot be traced stratigraphically in this locality, I still feel disposed to admit it does occur.

I have adhered strictly to stratigraphical evidence in writing the above report, and have not quoted any lists of fossils, as, although we

have good collections from all the beds mentioned, I do not think it advisable to publish lists until these lists can be perfectly reliable as regards the names.

With regard to the pleistocene formations, I have nothing further to add to what is already known of these beds—save to point out that a greater extension of volcanic beds exists than has been mapped by Captain Hutton—as certain quartzose sands will have to be considered under this head, as I have seen them distinctly associated with, and overlying lava streams.

NOTES ON THE GEOLOGY OF THE JACKSON AND CASCADE VALLEYS.

BY D. MACFARLANE,

Government Resident Agent, Jackson's Bay.

Memorandum by Dr. Hector.

THE following report was received from the Chief Surveyor of Westland, and refers to a district between Jackson Bay and Big Bay, which has not yet been visited by any officer of the department.

The map shows the continuous development of the belt of magnesian rocks from near Jackson's Bay to Martin's Bay.

The specimens indicate that this belt consists of serpentine and dunite, and that it is bounded to the east by the mica schist formation of the Otago Gold Fields; while along its western junction the Maitai slates (the auriferous series of Reefton) appear, overlaid by the conglomerates and sandstones of the coal formation.

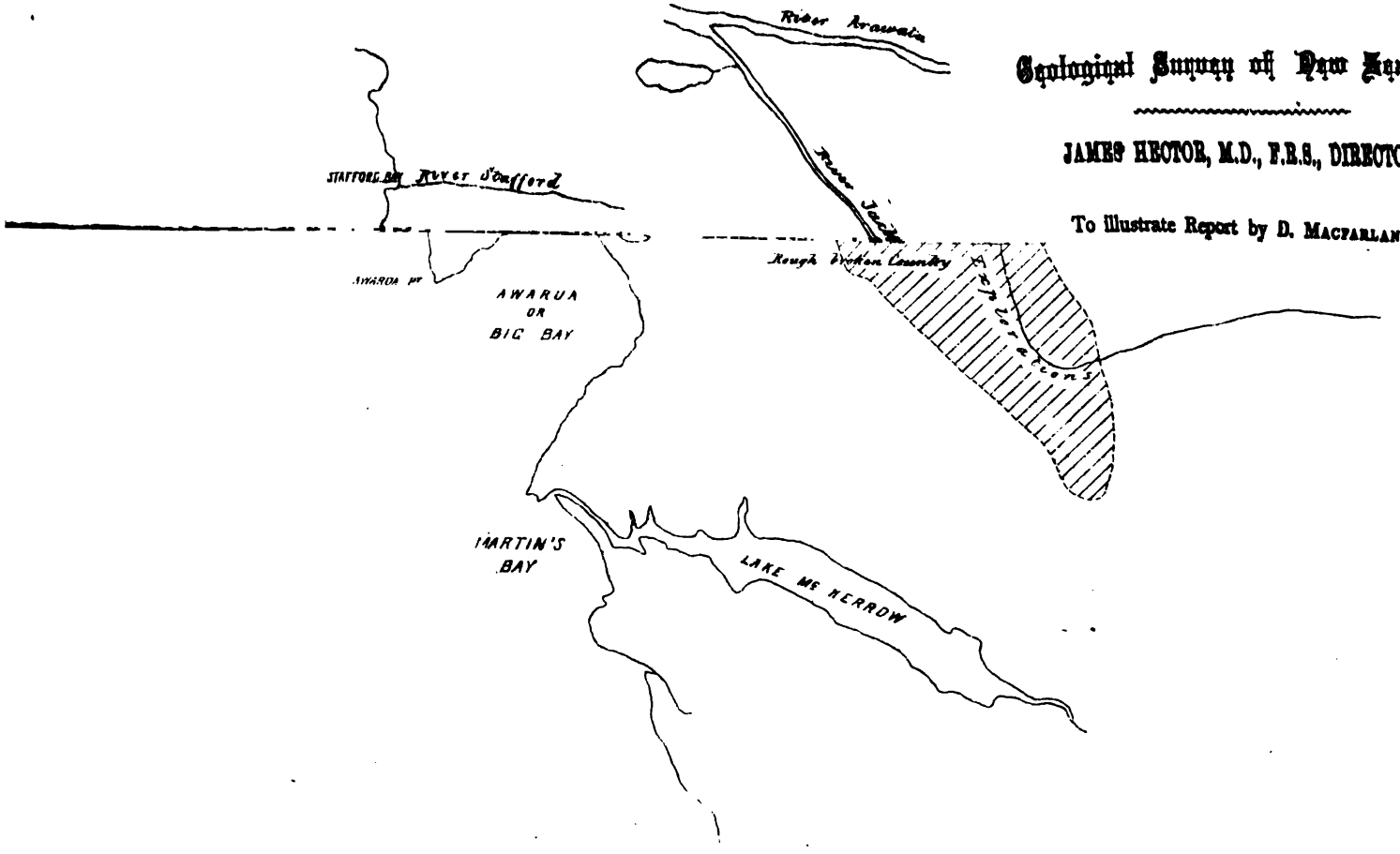
The following is a list showing the nature of the rock specimens submitted:—

No.	Mark.	Nature.
1.	X.	Serpentine.
2.	II.	Serpentine, with chert.
3.	I.	Green talc.
4.	$\frac{A}{X}$	Dunite.
5.	$\frac{B}{X}$	Dunite (decomposed).
6.	XII.	Schistose quartz, with pyrites from reef (auriferous).
7.	B.	Grey arenaceous sandstone from west of above. Altered Maitai (?); VII. 6.
9.	III. IV. V. VI. VII. VIII. XI. X. XII. XIII. XV. XVII.	Mica schists, similar to Dunstan Gorge, Otago. VIII. has magnetite, and IX. pyrites.

REPORT.

THE presence in Jackson's Bay and neighbourhood of large masses of igneous and metamorphic rocks, pointed to the existence of an igneous belt at no great distance inland; therefore, whilst engaged on other duties in connection with the Special Settlement, I took the opportunity, during a fortnight's exploration in the Jackson and Cascade Valleys, of noting the more salient points and features in the geology of those districts, thereby enabling me to locate the line of erruption from whence the rocks found along the coast have been derived. The results of my observations I now submit for your consideration :—

My route lay up the Arawata and Jackson Rivers, down the left-hand branch of the Cascade to its junction with the main stream, thence to within five miles of the point at which the river enters the sea. The main branch of the Cascade I followed up to the point marked A on the plan, about two miles below where the river comes in from the south-east. Seven miles above the junction of the Jackson with the Arawata, I met with the first indications of the igneous rocks *in sitû;* the belt, which is here about a mile wide, consists principally of the dark green hornblende, marked X (serpentine) in the series of hand specimens accompanying this paper, with various bands of No. 11 (chert) running through it, showing a slight dip to the eastward. The whole formation is very much broken up, the jointings of the dark hornblende being filled in with thin lamina of No. 1 [fibrous serpentine (Jade)]; this, on continued exposure to the atmosphere, turns into a white pasty substance, and presents a marked feature in the appearance of the country; as, for instance, where great slips have taken place recently the exposed rock shows a beautiful light green appearance, but after long exposure the green changes to white, streaking the ranges with immense white patches that have been taken, when seen from a distance, for quartz and pipe clay. The specimen marked (dunite) $\frac{X}{A}$ (not seen *in sitû*) occurs in large angular fragments all along the belt, the top of Mount Richards (from the top of which a complete view can be obtained on a clear day of the belt, north and south) being composed of an immense cairn of such fragments, piled up in indescribable confusion. The same rock is met with all along the Cascade Plateau to the sea, more particularly on the southern break of the terrace, bounding the lower reach of the Cascade Valley. The specimen marked $\frac{X}{B}$ (decomposed dunite) occurring in boulder form, is met with along the same line. The red appearance, which is the characteristic colour of the whole range, is due to the



Geological Survey of New Zealand.

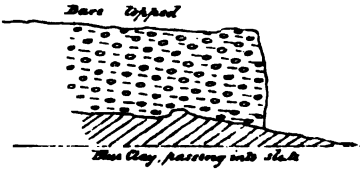
JAMES HECTOR, M.D., F.R.S., DIRECTOR.

To illustrate Report by D. MACFARLANE.

1876

Gravel and boulders
Cemented

Bare Upland



Blue Clay, passing into slate

Sea level at Cascade Bluff

reak of about twelve miles, Conglomerates are
n masses from head of Gorge on Cascade river
to Coal Lake, but underlying rocks unknown

oxidation of the mineral; the red, white, and green, forming as they do such striking contrasts, present a very remarkable appearance. The accompanying section, taken near the north end of the belt, together with hand specimens of the rocks as they occur, will better enable you to judge of the nature of the country than any description I could give. The auriferous lode, No. 12 (schistose quartz) is being prospected. I have failed in detecting free gold in the stone, and whether the pyrites will be rich enough in gold to pay for its extraction remains to be seen. The lode, which is of great width, and standing nearly vertical, lies about 60 chains to the eastward of the igneous formation, having a north and south strike; from this point, on the section line, the dip of the slates gradually alters, until, at their junction with the eruptive rocks, they show an angle of 40°. Whether the same sequence prevails further south, I am not in a position to state positively, but as seen from Mount Richards, the enclosing rock to the eastward is a dark well-defined slate, showing distinct cleavage lines, and standing nearly vertical, forming a bold escarpment, and apparently an abrupt termination, from the eruptive rocks to the dark slates, without the intervening green slates that are found further north; however, this is a matter requiring more careful and extended observations. Above a certain line the belt is entirely devoid of vegetation, and in many places it is bare to the foot of the range. The work of disintegration is going on very rapidly, great slips occurring very frequently, making travelling somewhat dangerous, as in attempting to cross some of those slips a very little disturbance sets hundreds of tons of the *débris* in motion.

From where the formation shows in the Jackson, the general course of the belt is S. 30° W., widening as it goes south, attaining its greatest width at the back of Big Bay, that is, presuming that the red hill at this point is of the same character as the country I traversed. My furthest south was about 23 miles, in a straight line, from the Jackson to a point where the main branch of the Cascade falls about 200 feet in about two chains, and within about two miles of where the river comes in from the south-east. From the Jackson to this point I found the formation cut through by the following streams, forming in many places deep gorges, viz., the Jackson River, left-hand branch of the Cascade, Woodhen Creek, McKay's Creek, Fall Creek, and, lastly, the Cascade River. This stream, after crossing the formation, has followed along the western line of strike for a considerable distance, but the belt keeps its course irrespective of the present valley formations

and other natural features that show at first sight. To the westward of the valley I find the slates and sandstones dipping to the west, at an angle of 30°. (Specimen B, slate, from Barn Bay Range, south side of Cascade Valley).

About a mile below the Cascade Saddle the left-hand branch enters a gorge, about two miles long. The river being very low, I managed to pass down through the gorge. The river having cut clear through to a depth of 150 feet in places, a fine section of the formation is presented, which consists of a heavy conglomerate, showing very complete stratification, having a very slight dip to the north-west. This formation continues right down to the sea, unless when cut through by streams, and forms the Cascade Plateau. The river has cut clear through the conglomerates, exposing the older slates beneath, marked A (micaceous sandstone), and upon which the conglomerates are lying unconformably, the slates dipping to the north-west, at an angle of 35°. At Teer's Creek, on the coast line, at high water-mark the underlying rock is exposed, consisting of a blue clay, passing into rock. Where this immense body of cemented wash has come from, and the process by which it has been so evenly distributed, is more a question for experts to deal with than for me to guess at; but, aside from all geological speculations as to the "whence and the how" of such things, I think a thorough examination of the country indicated would be productive of useful results, leading to important mineral discoveries which might be of great financial importance to the country, and attracting population to the coast, thereby developing the at present locked up resources of the West Coast.

REPORT ON THE KANIERI AND GREY RIVER COAL DISTRICTS.

BY W. D. CAMPBELL, C.E., F.G.S.,
Assoc. Inst.

Memorandum for Mr. Knowles by Dr. Hector.

12th February, 1877.

I FORWARD, for the information of the Hon. the Minister of Public Works, Mr. W. D. Campbell's report on the present state of the Kanieri and Grey River Coal Fields, which I was instructed to obtain by your minute of the 7th January last.

1. From this report there appears to be no fresh evidence of the existence of workable coal seams in the Kanieri district which will warrant further expenditure for explorations by boring or sinking.

2. The Brunner Mine is progressing steadily, considering the difficulty that has existed up to the present time in transporting the coal to the shipping port. The fault which throws down the coal to the north of the present workings is still unexplored, and it is unfortunate that a large expenditure of money and time has been squandered in fruitless driving in a direction contrary to that advised in former reports.

3. The new discoveries in the valley of Coal Creek, and towards the coast at Ten-Mile Creek, reported by Mr. Campbell, are very satisfactory, showing that the faults are unimportant, and that the strata continue to carry workable coal seams throughout the whole area where the formation crops out at the surface.

4. The exploration on the south side of the river by the Greymouth Company have proved the existence of the coal as anticipated; but I think it was a mistake not to put down the working shaft at the point where the ten-foot seam of coal was proved by boring, as, by doing so, enough coal would have been obtained to pay for further explorations, and the underground drives would have proved the exact nature of the faults which complicate the working of this part of the field. At the same time, I still adhere to my opinion that the proper place for the deep bore and shaft is that indicated in my plan of 7th April, 1873.

Instructions to Mr. W. D. Campbell by Dr. Hector.

13th January, 1877.

THE Minister of Public Works authorizes me to employ you to visit and report on the Kanieri Coal Field, some miles inland from Hokitika, with

the view of ascertaining if any fresh evidence has been obtained of the probable existence of coal in workable seams since the abandonment of the former exploratory works in November, 1873. The nature of these former works, and the distribution of the coal formation, you will gather from the accompanying documents and plans, of which you will provide yourself with a tracing.

On arriving at Hokitika, you will communicate with the Hon. J. A. Bonar, Government Agent, and be guided by his advice as to the best way of visiting the coal field. As you return, you will also visit Greymouth, and gather such information as will enable you to report on the conditions of the coal mines there, and their present and prospective output. To do this, it will be necessary to visit the mines on both sides of the Grey River, at the Coal Gorge.

REPORT.

7th March, 1877.

In accordance with instructions I had the honour of receiving from you on the 12th January, I examined the documents relating to the former Kanieri explorations, and in the Appendix will be found a *résumé* of the subject, and an abstract of correspondence.

I then proceeded to Hokitika overland from Nelson, and on my arrival, on the the 26th instant, I placed myself in communication with the Hon. J. A. Bonar, and, having been provided with a guide, proceeded on to the Kanieri district, and remained there till the 6th February, first examining the abandoned shafts and tunnels of the first Coal Prospecting Association, and then exploring the creeks in the neighbourhood.

The second, or new Prospecting Association, have put down two bores, one of which is about half way, in a S.W. direction, from the long tunnel to the right-hand branch of the Kanieri River, at 582 feet altitude, and 118 feet below the tunnel. It passed through 29 feet of gravel, and 45 feet 6 inches of bluish sandy clay, the upper part containing minute fragments of coal, and into 3 feet of grey sand; total depth, 77 feet 6 inches. This is probably a "wash" of the Kanieri blue marls; a similar deposit occurs in Coal Creek, at 840 feet altitude.

The examination of the creeks showed a series of dark red and blackish coloured sandstones, with thin bedded bands, underlaid by a red conglomerate, which is also seen underlying shales, with plant remains, at the old dam, Butcher Creek, dipping 20° to the N., while

higher up on the hill side it dips 40° to the N.E. This conglomerate is followed by clay slates, having the same general dip, varying from N.E. to E., but sometimes they are found dipping to the S.S.E. and N.E., as marked on plan, the angle of dip varying from 20° to 110°, or an inverted position, and are closely intersected by faults. The slates have a cherty character in places, with quartz veins in the line of bedding; these increased from 1 inch to 4 feet as higher beds beyond the limit of the coal-bearing strata were reached, the thicker veins having often a blue clay coating. In a creek flowing down from the high hill marked 2,719 feet on plan No. 1, the strata had chiefly an easterly dip; the quartz veins contained bosses of oxidized spathic iron ore and chlorite slate; and, at an altitude of about 1,700 feet, the slate was much disturbed, and had a southerly dip where last discernible, and was overlaid by decomposed granite and blue clay, dipping 35° to the south. These were highly charged with water. Solid granite appeared above this, forming the upper portion of the hill. A waterfall, 100 feet high, occurs here above the junction of the granite.

I was not able to find any further evidence of the existence of workable coal seams in the district. The seams in the workings appear to be of a very uncertain character, and at their high angle of dip would have to be over 10 feet in thickness of good coal in order to be worked profitably. At Dombrowa, in Poland, a seam at an inclination of 40° is worked, but it is 52 feet to 59 feet thick. The strata of the whole district are very much intersected by faults, being tilted irregularly down towards the granite and gneiss that cuts them off on the east.

Proceeding to Greymouth, I examined the Brunner Mine, and the shafts in course of construction adjacent to it, and the various outcrops of coal in Coal Creek and near Point Elizabeth that have been opened out by trenches and leased for working.

Brunner Mine.—Since the last report on this mine (see Appendix, 1 E.—3, p. 65, Journ. H. of R.), the workings have been increased during the years 1874, 1875, 1876, from 22 acres to 38 acres in extent (see plan No. 2). During these three years a total of 49,823 tons has been raised, according to the royalty returns.

Since September, 1876, barges have been discontinued, and coal has been conveyed to Greymouth by railway, though the bridge at the gorge is not yet finished—a wire rope and travelling truck being used to carry the coal across the river from the shoots to the railway trucks. The working capacity of this rope is about 150 tons per day, the greatest

being 12 tons per hour. A new incline line has been made from the interior of the mine to the new shoots.

An attempt has been made to prove the fault that limits the workings on the north by means of an upward drive of about 230 feet into the face of the fault, at the point marked B on plan No. 2, reaching a distance of 150 feet from the face, and passing through a vertical height of about 60 feet of strata. It was in progress at the time of my visit, and was made apparently in the belief that the fault would prove an upthrow, notwithstanding all that has been stated to the contrary in previous reports. I was able to identify two varieties of rock shown in it, and another from a small drive a few chains higher up in the mine (at C), as being the same as strata passed through at a height of 330 feet to 390 feet above the coal in No. 2 shaft (drawing No. 3). The stratum, with a calcareous bed (marked "fire-damp" in section), and the overlying dark sandstone, and the dark calcareous conglomerate, with *Cardium brunneri* from the adjacent drive, are clearly the same in both shaft and fault.

The slack from the screens is thrown into the river at present; this waste might be provided against in future leases, as it could probably be sold at 7s. or 8s. per ton in Greymouth, and the royalty returns would also be increased. The system of water-level drives, worked since Mr. Burnett's Report in 1868, (to the Commissioner of Crown Lands, Nelson), enables the mine to be kept in fair order and well ventilated. The irregular form of some of the workings in progress is mainly due to the "bords" being driven wherever the undulating form of the contour levels takes them, the coal being worked down to the floor. More complete surveys, giving the levels of the various portions of the mine, would enable the workings to be kept more regular. The manufacture of fire bricks has been commenced; the fire clay, which is of a micaceous nature, forms a bed of about 5 feet thick below the coal, and is prepared by means of a crushing-roller and pan, worked by a portable engine. The kiln is capable of holding a charge of about 15,000 bricks. Six coke ovens have been constructed of these bricks, which turn out a very superior kind of coke, while a half-burnt kind, called "black ends," is much used as fuel for the locomotives on the railway.

Coal Pit Heath Works.—A lease has been taken of 770 acres by the Coal Pit Heath Company, adjoining the western boundary of the

Brunner Mine lease, and a shaft has been sunk at C, (plan No. 4), which reached the thick seam at a depth of 265 feet. The coal is of a rather harder nature than that at present worked. The shaft is rectangular, 10 feet by 5 feet 10 inches, lined with 3-inch black birch planking for 75 feet from surface. A horizontal engine of 30 horse-power is being erected for pumping and winding. Bucket lifts are being fitted for raising water for the present. This shaft will be ready for working in a few weeks.

Greymouth Coal Mining Company's Works.—On the south side of the river, shaft No. 1, described in the last report, 1874, but a section of which is given in drawing No. 3, was worked until the end of August, 1875, when it was closed, the coal proving to be of too soft a nature. A total of 3,359 tons was raised from the workings at this shaft. Shaft No. 2 was then sunk to a depth of 415 feet, and boring was then commenced, and coal, 16 feet thick, reached at a total depth of 635 feet, (as anticipated by Dr. Hector, see Report, 1874). Sinking was then resumed, and the shaft is now 437 feet deep. It is circular, 11 feet in diameter, lined with fire brick laid in cement for 28 feet from surface. A 40 horse-power horizontal engine has been erected for pumping and winding. The pumps are two sets of 10-inch lift and force pipes.

Mr. Ronayne, the Manager of the Brunner Railway, estimates the line as capable of conveying 1000 tons per day with the present rolling-stock; and when the three mines are at work, this daily amount would be reached were there a succession of vessels loading at the wharf. The largest shipment in one day hitherto has been 250 tons; only occasionally is there a demand for 200 tons per day. The average per week, carried by steamers, is at the present time 198 tons, and by sailing vessels, 222 tons; total, 420 tons. This has been the average weekly for the past fifteen weeks, the largest cargo being 300 tons—this is by a vessel built specially for this coast service, and having a draught of 9 feet 6 inches only. The bar limits vessels to within 9 feet and 10 feet draught, the average tonnage being scarcely 150 tons.

The following table gives details of the coal raised and shipped, and shows the local consumption :—

TABLE SHOWING THE QUANTITY OF COAL RAISED AND EXPORTED AT GREYMOUTH, 1874 TO 1876.

	Coal Raised (Royalty Returns).			Coal Exported (Customs Returns).			Local Consumption by Deduct.*
	Brunner Mine.	Greymouth Coal Mine.	Total.	Foreign.	Coastwise.	Total.	
1874	13,730	...	13,730	1,722	10,653	12,375	1,355
1875	17,266½	3,359	20,625½	3,185	13,834	17,019	3,606½
1876	18,837	...	18,837	1,766 coal ·53 coke	14,295	16,114	2,723
	49,833½	3,359	53,192½	6,726	38,782	45,508	7,684½

The present price of coal, delivered on board, is 14s. per ton for vessels when in ballast, and about 18s. per ton when in freight; while the price for Greymouth consumers is 28s. per ton delivered, coke being 50s. per ton. The locomotives are supplied at 12s. 6d. per ton, but for these "black ends" is preferred; its price for this purpose is 20s. per ton. When the other mines are opened, there will doubtless be a diminution in these prices; and the companies could also own jointly a steam tug, the charges being at present 5s. per ton for vessels entering in ballast, and 15s. per ton when in merchandize.

Coal Seams in the Coal Creek Company's Lease.—Two seams of a very fine coal have been discovered, within the last eighteen months, cropping out on the east side of Coal Creek, about five miles from Cobden. These consist of a 6-foot and a 10-foot seam below. The outcrops are about 7 chains apart, and dip 22° S. 30° W.; they are thus about 170 feet apart, with light-coloured sandstone above and below them. A lease has been obtained this year of 1,036 acres, extending from the creek at this point to the Brunner lease. The country along the track to the outcrops is mostly a flat terrace district, except the last half-mile, and is favourable for the railway line projected for opening up the coal here and at Point Elizabeth.

About two miles N.W. of these outcrops a coal seam 7 feet thick has been discovered in the Seven Mile Creek; a specimen of coal obtained from there is evidently from a continuation of one of the last-mentioned seams.

* The local consumption for the last six months has been 1,500 tons, according to Mr. Kennedy, which shows that the comparison of the two returns gives a very fair result.

Point Elizabeth Coal Mining Company's Seams.—A lease has been obtained by this company of 3,840 acres, extending three miles along the coast north of Greymouth, beyond Point Elizabeth. Several outcrops of coal, from 4 feet to 16 feet thick, have been opened up in the various parts of the district: these are marked upon the accompanying plan. That occurring in the sea cliff, at the Nine Mile Bluff, was noticed in Dr. Hector's Report, 1874, and an analysis of the coal given. This seam is 4 feet 6 inches thick in its thickest portion, dip 11° W., and is cut off by a fault running N. 45° E.; it thins out rapidly southwards, and vanishes at 300 yards. The outcrops marked A, B, C, D, E, and J, are probably belonging to the same seam. At A, about a quarter of a mile inland, and at 190 feet altitude, the seam is 6 feet 6 inches thick, nearly horizontal, in light sandstones, with 15 feet of light-coloured conglomerates below it. At C and D, at 420 feet, and at 440 feet altitude, the outcrops are a few chains apart; but the thickness of the coal is 16 feet 9 inches at D, while it is only 4 feet at C; this is probably only an irregularity, and the seam may resume at a short distance the 6—7 feet thickness as before. The dip is 14° S. 65° W. At E, at 380 feet altitude, the dip is 15° S. 85° W.; the coal is 8 feet 6 inches thick, and of a harder and brighter feature than at the other outcrops.

This seam appears at the Nine Mile Bluff, where it is 4 feet 6 inches thick, but thins out rapidly to the south, and vanishes at 300 yards; at its north extremity it is cut off by a downthrow. The strata dip below the valley at the Nine Mile Creek, and rise again on the other side, the coal seam being seen at a considerable height on the south side of the Ten Mile Creek, where it is from 2 feet to 6 feet thick, and has been burning for four years.

The general character of this coal is of the kind called cannel, and it would probably be valuable for gas making; for this purpose the coal at C, D, and E might be worked; but that at A contains a considerable amount of iron pyrites, which would render the gas sulphurous.

At the Ten Mile Creek five outcrops have been opened up, but I was able to examine only one on account of the damming-up of the creek—some 30 feet to 40 feet—by slips that have taken place at the burning upper seam. These outcrops are about one mile from the coast, their thickness varies from 7 feet to 10 feet, dip 12° S. 80° W., but a little further up the stream the dip is slightly to the east; they occur in alternations of sandstone and conglomerate beds, at several hundred

feet below the burning seam horizon, which is marked very conspicuously by a white sandstone conglomerate; this bed, however, almost disappears toward the south part of the lease. The coal, though containing sandstone pebbles, is of good quality, resembling somewhat that of the upper seam, but having more of the "splint" character in its appearance.

At the Eleven Mile Creek, coal occurs in the green-coloured conglomerate that lies between these two seams, and which has intercalated patches of sandstone with carbonaceous markings, showing thin coal occasionally. A 4 feet 6 inch seam occurs here in a sandstone of this kind. The coal is of a very fine quality, but of uncertain extent. The rugged character of the gully renders it very inaccessible. Outcrops marked H and I on plan.

The hill face forming the coast line from near the Seven Mile Creek to the Nine Mile Bluff, and to about a quarter of a mile inshore, is composed of concretionary blue clays, underlaid by marls and limestone bands, containing *Nummulites;* these are faulted against a face of sandstone and conglomerate, in which the coal seam at A occurs.

I have been indebted to Messrs. Kennedy, Ronayne, and Loudon for the coal statistics of Greymouth; to Messrs. Moss and Simpson for particulars of the Greymouth Coal Company's shafts; to Messrs. Nancarrow and Taylor for those of the Coal Pit Heath shaft; to Messrs. Hindmarsh, Young, and Fowler for their assistance in showing me the outcrops in the new leases; and also to Messrs. Young Brothers for maps of the district. I also obtained further particulars of the Brunner Mine from the Waste Lands Board Office, Nelson, and from Mr. Chambers, their Inspector.

To accompany the above Report.

APPENDIX.—Summary of Kanieri explorations and abstract of correspondence. List of specimens collected.

Plan 1.—Plan of the Kanieri district.

Plan 2.—Working plan of the Brunner Mine, showing area worked over during the years 1874, 1875, and 1876.

Plan 3.—Sections of the new shafts at Brunnerton.

Plan 4.—Plan showing position of the above.

Plan 5.—Plan showing the positions of the coal outcrops at Coal Creek and near Point Elizabeth.

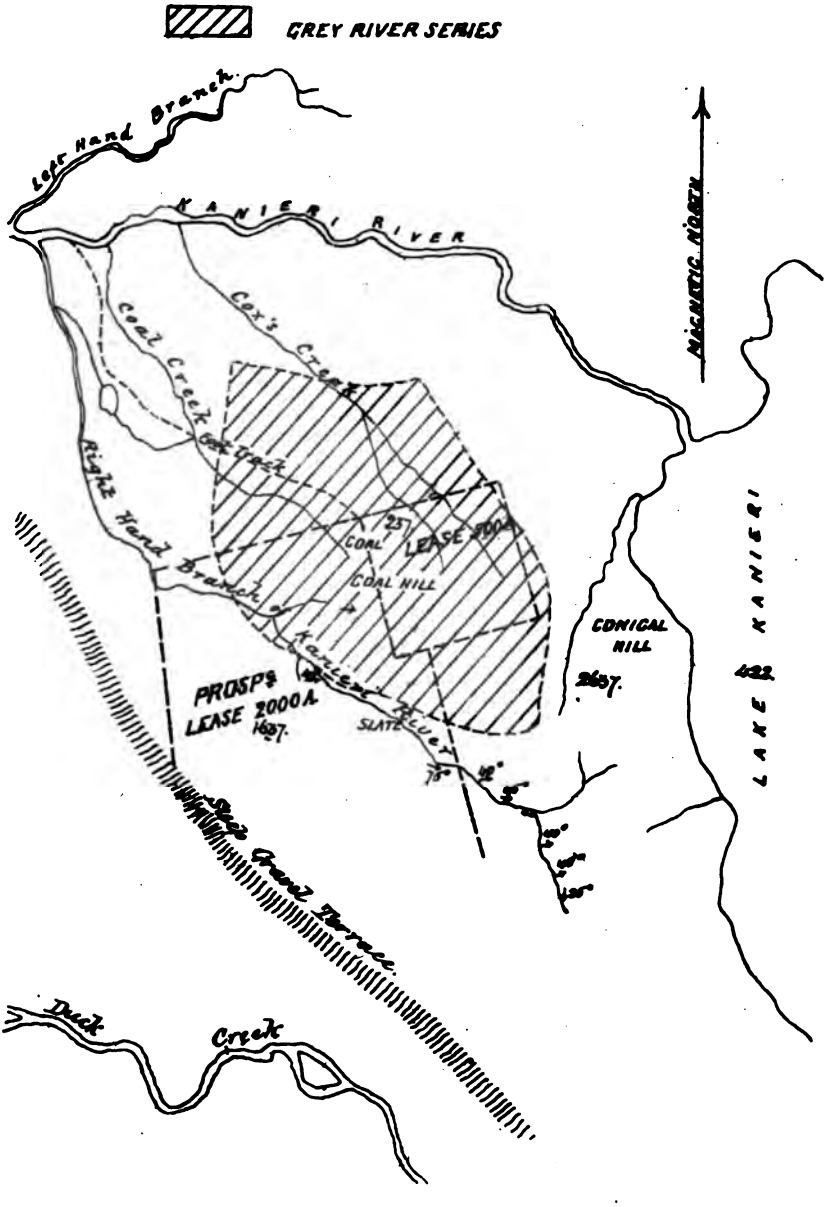
Geological Survey of New Zealand.

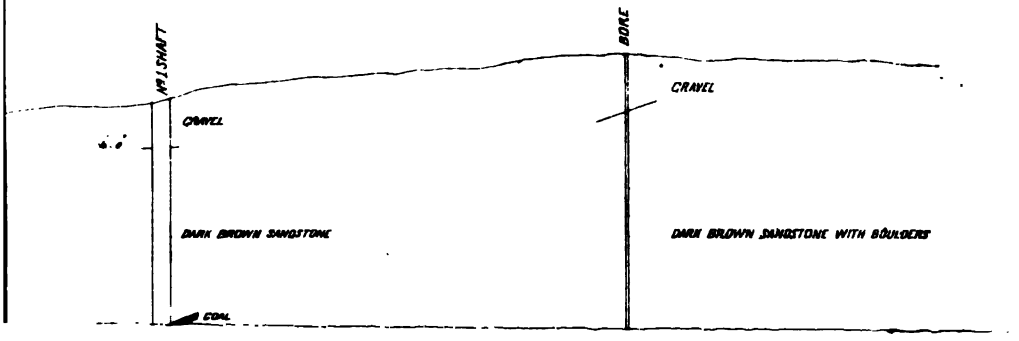
JAMES HECTOR, M.D., F.R.S., DIRECTOR.

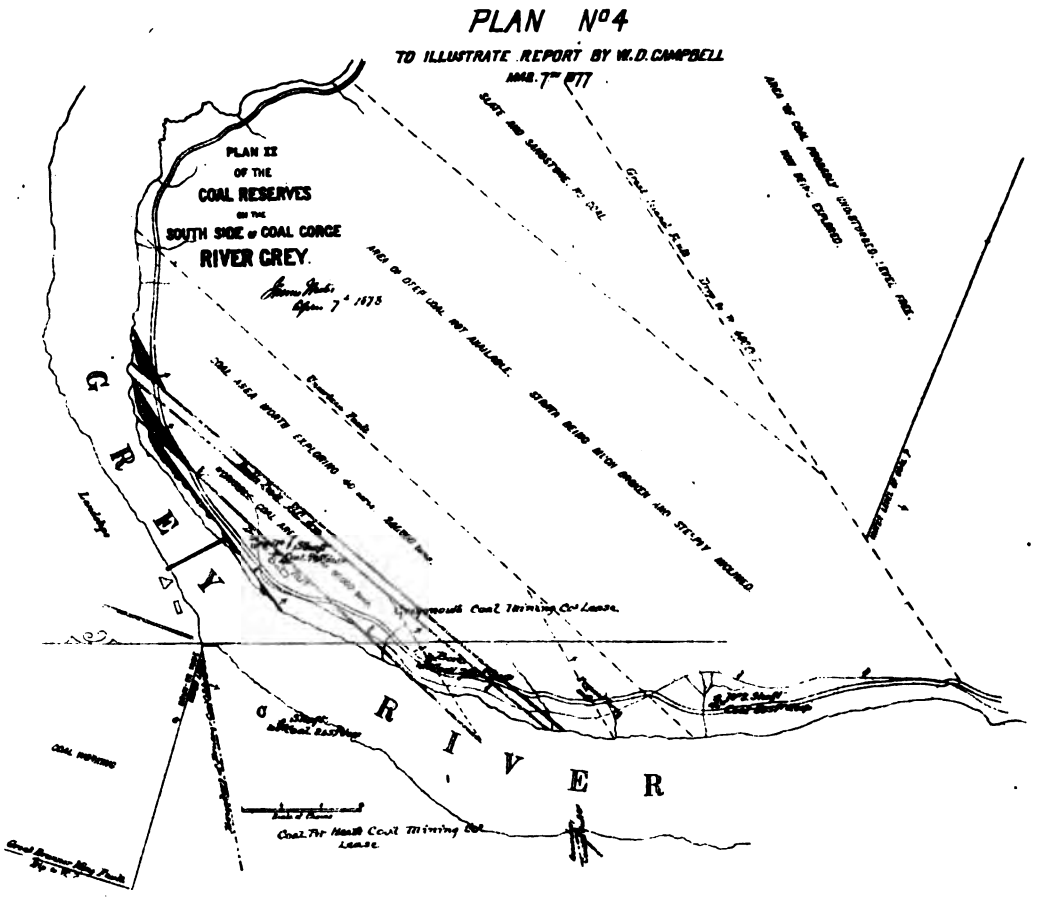
PLAN No1

TO ILLUSTRATE REPORT BY W.D. CAMPBELL

MAR. 7th 1877.




AIR SHAFT
BORE
GRAVEL
GRAVEL
DARK BROWN SANDSTONE
DARK BROWN SANDSTONE WITH BOULDERS
COAL


PLAN No 4
TO ILLUSTRATE REPORT BY W.D. CAMPBELL
MAR. 7th 1877
PLAN II
OF THE
COAL RESERVES
ON THE
SOUTH SIDE of COAL GORGE
RIVER GREY.
SLATE AND SANDSTONE, NO COAL
AREA OF OTHER COAL NOT AVAILABLE.
SEAMS WORKED WITH SHAFTS AND STEEPLY INCLINED
COAL AREA SHORTLY EXPLORING 40 acres MORE
Dunsmuir Coal Mining Co Lease.
GREY
RIVER
Coal for Heath Coal Mining Co Lease.

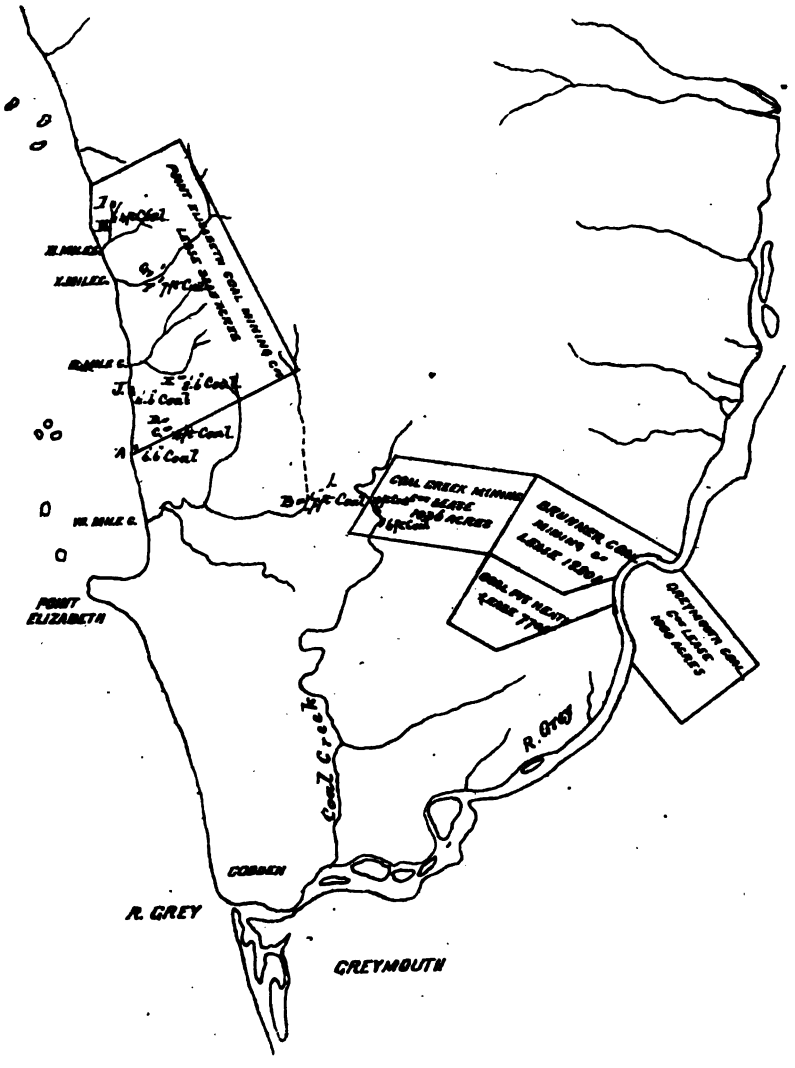
Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S., DIRECTOR.

PLAN No. 5

TO ILLUSTRATE REPORT BY W.D.CAMPBELL

MAR. 7TH 1877.



APPENDIX.

Summary of Kanieri Explorations.

THE first discovery of coal in the Kanieri district was in July, 1870. The strata then found were reported on by C. Y. O'Connor, Esq., at the request of the County Chairman, and his report, with plans, sections, and specimens, was forwarded to and reported on by Dr. Hector in December, 1870. In October, 1871, a meeting took place in Hokitika, and the first Kanieri Coal Prospecting Association was formed, which applied to the Waste Lands Board for a reserve of 500 acres for a temporary period of four months. This was obtained on 7th November, 1871. This time has been extended indefinitely by a protection order by the Board. Nothing further was done until, in 1872, fresh discoveries were made on the east side of Coal Creek; the former discoveries being on the west side. Explorations were then made in Parnell's Creek, and the "Prospector's Trench" was cut, which showed several coal seams, 6 inches to 6 feet thick, in a vertical position; and the "upper" shaft was sunk 44 feet on the 6-foot seam, which was found to have a sandstone parting dividing it into two small seams.

On 21st June, 1872, G. Müeller, Esq., reported upon the works at the request of the County Chairman; careful surveys and sections were made to accompany the report. A tunnel was recommended to be driven to intersect the vertical strata at 200 feet from where the outcrop appeared. This, however, was not carried out. Dr. Hector, on receiving the report from the Minister of Public Works, and on additional information being supplied by the Secretary of the Association, recommended shallow surface pits and trenches for searching for outcrops of coal seams.

In October, 1872, Mr. Bonar furnished to the Government a memorandum of the action taken by the Association, and a grant of £300 was made for defraying the expenses incurred in prospecting works for further opening up the strata, so as to enable Dr. Hector to examine them to advantage at a projected visit.

In March, 1873, Dr. Hector visited the district, and recommended a further grant, and a sum of £100 was accordingly allowed; and this, by Dr. Hector's direction, was used in driving a tunnel to intersect a seam shown in a surface trench 17 chains S.S.W. of the old tunnel, and at 700 feet altitude.

In September, 1873, a further grant of £100 was made. The tunnel had been driven a total length of 305 feet, and a 5-foot seam

met with, dipping 45°. A shaft was sunk 42 feet from the floor of the tunnel, and the seam was found to run into hard shale. Operations were then discontinued until the present time, when two bores have been put down (without success, however,) by the second Kanieri Coal Prospecting Association. This Association obtained a prospecting license, in 1876, for one year, over 2,000 acres, adjoining the first lease.

OAMARU AND WAITAKI DISTRICTS.

Memorandum of Instructions to Mr. McKay.

I WISH to obtain the material requisite for the classification of the cretaceo-tertiary beds that skirt the Canterbury Plains, from the Waipara southwards to Oamaru. These comprise :—

1. Upper Ototara or Mount Brown beds, or Curiosity Shop beds.

Chalk group
2. Grey marls.
3. Weka Pass stone, Oamaru stone, and calcareous green-sands ;—being the Ototara beds proper.
4. Amuri limestone.
5. *Leda* or chalk marls.

The above constitute the group I have hitherto included under the term cretaceo-tertiary ; though, perhaps, No. 1 should be classed separately as upper *Eocene*, and this is one of the chief points to be attended to.

You will proceed to the Middle Waipara, taking assistance with you for the collection of any Saurians you may discover in the lower beds without delaying your proper work; examine the Mount Brown beds, making a small collection (one or two of all except the more remarkable forms will be sufficient); endeavour, when at the Waipara, to obtain some more fragments or the whole of the specimen from which you formerly broke off the Megalosauroid tooth, as it is the first evidence we have had of the presence of land Saurians in the Waipara series.

From Mount Brown trace the outcrop of the limestone in the direction of the White Rock Quarries, and observe carefully if Nos. 3 and 4 be present there. If you see any Saurians there in the lower beds, you can leave instructions for having them worked out by your assistant. Visiting the Okuku River, proceed by the Ashley to Glentui, and examine and collect from the base of the green-sand formation there; thence, by way of Oxford,—where the *Conchothyra* beds are reported, and from whence the highly mineralized (bird?) bone was received—to the Gorge Ferry. Examine the sandstones and conglomerates at the base of Jebson's coal series, exposed in the valley where his house stands, and go thence by rail to Temuka, where you will first visit the Kokohu Valley, where there are both fossiliferous

limestones and highly altered limestones, locally known as marbles. These latter are associated with jasperoid slates and quartzites, and may, perhaps, be an exposure of the Reefton beds.

Thence cross the range to the Opihi River, where fossils occur in connection with the coal beds. Trace these beds up to the Pareora horizon, and, as this has been selected as a typical locality by some, get a good collection from the younger formations exposed there.

Continuing southwards, proceed to Oamaru, and, getting assistance if necessary, make a good but select collection from all the beds in the district as far south as Otepopo, paying a flying visit to Moeraki. Observe the relation of the Oamaru Cape and Hutchinson's quarry beds, with the interbedded volcanic rocks and the Oamaru sandstone (No. 3?) of Fortification Hill; also to the Awamoa beds. Trace the relative position of the No. 3 beds to the calcareous green-sand of Waiareka, which yields fish teeth and tusks, and which is probably the equivalent of Nos. 1 or 2. If this is the case, you may be able to run the section back in descending order N.E. to Big Hill, where coal beds crop out, dipping to the S.W. off schistose rocks, east of Awamoko.

The other limb of the syncline, of which the beds No. 1 will be the centre, if not overlaid by *Miocene* strata, can be followed south from the mouth of the Kakanui, through Otepopo, to the ranges. If you fail to see the chalk marls, No. 5, or any of the beds lower than No. 3, in this section, you will require to visit Moeraki Bay, and round towards the old Wharf you will find light-coloured *Turbinolia* marls that represent these lower beds. If you find them to do so, endeavour to find their relation to the ferruginous sandstones of Onekakera beach. Bear in view the probable existence in the district of a series of N. and S. faults, with downthrow to the west, that keep setting back the strike of the beds, and causing an apparent overlap of the upper members and absence of the lower. You will finish up towards the Maraewhenua junction with the Waitaki, and go up as far as the coal crop above the Honourable Mr. Campbell's Station; and, if you think it requisite, re-cross the Waitaki, examine Elephant Hill, and make your way north to rejoin the railway at Temuka by any line of country you consider best.

6th November, 1876.

NARRATIVE.

January, 1877.

IN pursuance of the above instructions, I left Wellington on the 7th of November last, leaving Christchurch for the Waipara on the 11th, arrived at which place, exceptionally bad weather detained me till the 20th November.

This delay prevented my visiting either the Ashley Gorge, the Oxford district, or the Malvern Hills, besides greatly impeding my work in the Waipara district.

On the 21st November I examined the White Rock Quarries, and the associated beds in the creeks falling into the Grey Stream; and having satisfied myself as to the general sequence in this district, I returned to Rangiora, the Ashley River being yet in a flooded condition, and thus preventing my following the route laid down in my instructions. Fearing that the time at my disposal would no more than suffice for an examination of the more important southern localities mentioned in my instructions, I postponed the intended examinations near Oxford and at the Malvern Hills, and, on the 22nd November, travelled by rail to the Orari and thence by coach to Geraldine, reaching the neighbourhood of the Kokohu on the 23rd.

In this district I remained collecting from the various formations there exposed till the 1st of December, on which date I left for the Pareora district, crossing the Opihi River four miles above Pleasant Point, and thence making my way through the downs to the cave on the Tongawai River. Next day I passed into the Upper Pareora, and remained there collecting till the 5th December. On the 6th December, and the morning of the 7th, I examined and collected from the lower gorge of the Pareora and from the Pareora beds under Mount Horrible, arriving at Waimate on the evening of the 7th.

On the 8th of December I arrived at Oamaru, and employed the time between the 9th and the 18th of December in examining and collecting from that part of the Oamaru district east of the Waiareka Creek.

Between the 18th and the 22nd December I examined the middle part of the Waiareka Valley; the country south of Big Hill containing coal; also the neighbourhood of Herbert, in the Otepopo district.

The 23rd and 24th December were stormy.

On the 25th December I followed up Landon Creek, examining the limestone there and at the Devil's Bridge on the Oamaru Creek, and thence passed into the Waiareka Valley, from which on the following day I examined a part of the country between this and the Kakanui River, and a portion of the western banks of the Kakanui itself.

On the 27th I left the Waiareka for the Maraewhenua, crossing the ridges to the Awamoko Creek, reaching the Waitaki Valley at the

Black Point, and thence following the limestone cliffs to the Maraewhenua River.

In this neighbourhood I was employed till the 30th December collecting from the limestone and overlying beds, as well as from the coal beds, where these are fossiliferous in this neighbourhood.

On the 31st December I examined certain fossiliferous green-sands, in connection with the gold workings, ten miles up the Maraewhenua River; and on the 1st January, 1877, returned to Oamaru with the collections made in this district.

From the 2nd till the 4th January I made further examinations of the ridges east of the Oamaru Creek, packed and despatched the collections, and on the 5th January left Oamaru on my return journey, arriving at Christchurch on the 6th and Wellington on the 10th January; the trip occupying sixty-three days.

Notes referring to the Collections made.

WAIPARA DISTRICT.

Mount Grey Downs.—On the north branch of the Kowai River I obtained a few shells from the sandy beds that underlie the heavy beds of gravel which form the Mount Grey Downs.

Individuals are very abundant, but at this point two species, *Pectunculus laticostatus* and *Ostrea lutraria*, seem to be the only shells present.

Mount Brown Beds.—From these I obtained a small collection, but nothing of especial interest. I noted the association of *Pecten hochstetteri* with the cup-shaped *Bryozoa* in the upper members of this division.

Grey Marls.—From these beds I made no collection, fossils being rare in them in the Waipara section.

Weka Pass Stone.—The only fossils which attracted my attention in this division were contained in a fallen mass, now lying in the river bed, in which ribs and vertebræ of what appeared to have been a *Cetacean* were present. Only for the sudden rise of the river I should have secured this specimen, but it may, however, be reached at any time when the river is moderately low.

Amuri Limestone and Chalk Marls.—From these beds but few fossils have hitherto been obtained, nor was I more fortunate on this occasion. Large *Fucoid* impressions, as at the Amuri Bluff, cover the surfaces of the detached blocks. Some of these are three feet in diameter, and are very beautiful. The only specimens collected were

samples of the underlying chalk marls for microscopic examination; minute shells being visible.

Green-Sands.—The beds comprising this division are in the Waipara generally unfossiliferous. Shark's teeth are often found in the higher beds, and in the lower some very large ribs belonging to *Plesiosaurus crassicostatus* were found by me in 1874. Many concretions occur in the lower part of these green-sands, which contain many fragments of plants, but none in a state which admit of identification.

Grey Sands (Saurian Beds, etc.).—In May, 1872, while collecting here for the Canterbury Museum, I observed that the Saurians were generally found in the concretions from the lower part of these sands, while the boulders from the higher part seldom contained Saurian remains. The boulders are generally devoid of fossil shells of any kind, but several boulders from this horizon are full of marine shells, and occasionally a *Dammara* or Dicotyledonous leaf is seen. I obtained a *Belemnite* from the same boulder which on a former occasion yielded both *Dammara* and Dicotyledonous leaves, and many shells of a less secondary type. These are now in the Canterbury Museum.

Coal Beds.—Although there are in the district some thin seams of sufficient purity to burn, these beds are oftener represented by impure sandy shales, overlaid by the Black Oyster bed. From a block of this carbonaceous matter I obtained several specimens of a *Pholas*, in many cases still filling its burrow; and from masses of ironstone, associated with shales and conglomerates, underlying the coal horizon, some specimens of Dicotyledonous leaves.

Several fine specimens of Saurian remains might yet be obtained from the grey sands of the Waipara series, but as all the more accessible ones have been secured, these could only be procured at considerable labour and expense.

District of White Rock Quarries and Neighbourhood.

Mount Grey Downs.—In following up the south-west branch of the Grey Stream no fossils are to be found in the higher gravels which form the Mount Grey Downs, and which here are exposed as high cliffs on the south-west bank of the creek. Gradually these become finer grained, till beds of brown sands appear, underlaid by a thin seam of lignite. The beds below this lignite seam are blue sands and fine-grained pebble beds, with abundance of fossil shells. I did not make a collection from these beds, as the time at my disposal was very limited.

Mount Brown Beds (White Rock Stone).—In the Grey Stream these beds have in the bed of the creek no great thickness, and few fossils are to be seen. Immediately to the N.E. and S.W. the limestone thickens out considerably; and at the White Rock Quarries is, in places, highly fossiliferous, *Pecten hochstetteri* and *Pecten hutchinsoni* being the most prominent. *Meoma crawfordi* is plentiful, and of great size. Corals and spines of Echinoderms are abundant in the higher beds, with considerable numbers of the cup-shaped *Bryozoa* of Mount Brown. I brought with me only a few of the smaller fossils.

Grey Marls.—These beds are well seen in the gorge of the S.W. branch of the Grey Stream, and are full of characteristic fossils (*Foraminefera* and small shells). Of these I brought specimens with me.

Weka Pass Stone.—This rock, which in the Waipara district is so calcareous as to be properly called limestone, is here little more than a slightly calcareous green-sand. It contains in this place *Pecten hochstetteri*, *Voluta elongata*, and casts of a *Dentalium*, Echinoderms in a broken state, and numbers of a species of *Waldheimia*, but not often in a good state of preservation; this bed is not to be distinguished at the White Rock, except as a bed of green-sand underlying the Mount Brown beds, from which latter the building stone is obtained.

Amuri Limestone and Chalk Marls.—These beds which seem to be entirely absent in this district, are represented by a considerable thickness of grey sands with concretions. No fossils were seen in this or the underlying green-sands.

Notes referring to the Collections made.

KOKOHU DISTRICT.

Pareora Beds.—These are brown sands underlaid by blue or green sands, and often containing hard blue concretions, mostly crowded with fossils. In the higher beds the fossils are free in the sands, but often exist as casts only. A small collection was made at this point, as I considered a large one unnecessary, in view of the collection to be made from the typical locality in the Pareora River.

Weka Pass Stone, (Calcareous Green Sand).—A few fine specimens of *Meoma crawfordi* and *Pecten hochstetteri*, besides others, were obtained, but the beds are not rich in species, although some of the forms, as for instance *Pecten hochstetteri*, are in places exceedingly plentiful.

Amuri Limestone and Chalk Marls.—These are present as the beds immediately underlying the Weka Pass stone; but, as far as yet

examined, no fossil shells have been found in them. Specimens for microscopic examination were obtained.

Green-Sands.—These beds, which, in their upper part, pass insensibly into the chalk marls, have, in their middle part, where they become intensely green, a considerable variety of fossils, from which a good collection was made, amongst which were specimens of *Ostrea carbonacea* and *Cardium brunneri;* the first occurring in the Nine-Mile Bluff, north of Greymouth; the last in the beds overlying the coal at Brunnerton. In their lower beds, immediately overlying the coal, they are full of a considerable variety of shells which, including the above mentioned, have in addition, a considerable number of undetermined species; from these a considerable collection was obtained. From light-coloured fire-clays, which occur in association with the coal beds, Dicotyledonous leaves and other plant remains were obtained.

Old Slate Formation.—From these beds a suite of rock specimens, comprising white, grey, and blue crystalline limestones; blue, green, and reddish slates; grey and reddish quartzites, were collected in the gorge of the Kokohu River.

PAREORA DISTRICT.

Pareora Beds.—From these beds a considerable collection was made from beds of loose shell conglomerate, near the junction of the White Rock River with the main branch of the Pareora, and also from the blue sandy clays exposed in the southern base of Mount Horrible, and from the ridges on the south side of the river. This collection, which comprises eighty different species of shells, mostly in a fine state of preservation, contains *Turritella gigantea, Natica solida, Ancillaria, Conus, Scalaria, Dentalium, Cardium* (large), *Crassatella, Pecten hochstetteri,* and many others.

Weka Pass Stone, Amuri Limestone, and Chalk Marls.—From the first of these a few fossils are to be obtained in the river bed, near the junction of the Little River, principally *Scalaria, Waldheimia,* and Echinoderms.

In the Chalk Marls nothing was to be seen.

Brown and Grey Sands.—These beds, which underlie the chalk marls on the south side of the gorge, have no fossils, except a few shark's teeth scattered through them; unless some beds of shell conglomerate exposed in the road-cuttings at the upper end of the gorge should prove to belong to these lower beds.

Oamaru District.

Awamoa Beds.—A considerable collection was obtained from these beds, near the mouth of the Awamoa Creek.

Hutchinson's Quarry (Mount Brown Beds).—At several parts collections were made from these beds, the principal one being at the Old Lime Kiln Quarry, at the Devil's Bridge, in the Oamaru Creek, and one mile further down the creek, on the spur between the two branches of the creek.

Ototara Limestone.—Fossils are rare in this rock, and as it is followed in many places by the Mount Brown beds, apparently conformably, fossils belonging to the latter may easily be confounded with the Ototara beds.

Tufas underlying the Ototara Limestone.—These are not usually fossiliferous, but at one or two places in the sea cliff, near Oamaru, they are so. From this locality a small collection was obtained from the railway cuttings, near Cave Valley, consisting of fine specimens of chalk, almost wholly composed of minute *Foraminifera* remains. Black flints occur in this bed.

Green-Sands.—These beds contain shark's teeth in the Waiareka Valley, and on the Kokohu a few indistinct shells, but no collection of any value could be made from these beds in this district.

Otepopo District.

The only horizon in this district proved to be the higher part of the green-sands, which here are more marly than usual, and contain *Turbinolia* corals, *Foraminifera*, a few bivalve shells, and some plant remains.

Awamoko and Maraewhenua Districts.

Collections were made from these on the north bank of the Maraewhenua River, whence a considerable number of species were obtained; the beds appear to overlie the limestones at Maraewhenua quite conformably.

Weka Pass Stone—Ototara Limestone.

These rocks are in this district highly fossiliferous, and a good collection was obtained along the cliffs bordering the Waitaki Valley, south of the Maraewhenua, *Pecten hochstetteri*, *Meoma crawfordi*, and a *Waldheimia* being particularly abundant in the lower part of the limestone. *Cetacean* bones are also plentiful along the junction with the underlying green-sands.

Green Sands—which here take the place of the *Tufas*, which underlie the Ototara limestones in the Waiareka Valley, contain little but *Fucoid* stems in their upper part; but are, in their lower part, where they closely overlie the coal beds, highly fossiliferous. From these in the Waitaki Valley a considerable collection was obtained.

From this horizon, at the gold workings on the Maraewhenua River, a small collection was obtained from green sands overlying auriferous quartzose gravels, overlaid by beds of sandstone, full of marine shells.

Geology.

Considering it unnecessary in this report to make any remarks on the formation of the Canterbury Plains, the silts of Timaru Downs and Oamaru Cape are the youngest beds of which a description need here be given. These beds in both localities are exactly similar in appearance, and are most probably of contemporaneous origin.

At Timaru, fossils are rare, *Haliotis* and *Mytilus*, as broken fragments, occur in the cliff along the shore, north of the town. In the neighbourhood of Timaru, this deposit covers a considerable extent of country between the Pareora and Temuka Rivers, extending from the coast to the eastern slopes of Mount Horrible. At Oamaru they cover a considerably less extent of country, but are more interesting as they here contain a considerable variety of fossil shells in the thin beds of gravel which form their base; Captain Hutton having obtained twenty-two species, besides Moa bones, which are not uncommon in the higher part of the silts. Of these latter I endeavoured to secure several specimens, but found them very difficult of extraction in a perfect state. In one locality, on the south side of the Cape, I noticed two large pelvic bones, besides ribs, etc., but all of them proved so fragile that on attempting to extract them they fell to pieces. Leg-bones are frequently secured, being less decomposed.

The specimens above mentioned occurred in the lower part of the silt, closely overlying the gravels with marine shells. In the banks of a deep gulch forming the mouth of a small creek, which, rising on the south-west side of the Flagstaff Hill, falls into the sea at this place, in the close vicinity of where these moa bones were observed by me, the greater part of a skeleton was laid bare some time ago, which, from the descriptions given me, did not seem to have been that of a Moa. The first discoverers seem to have considerably mutilated this specimen, but Mr James Spence (an old resident in Oamaru) informed me that he extracted the remaining portions, and that there could be no doubt but

that the remains were human, he having secured the skull amongst other bones, but not thinking it of any importance, this was not preserved by him.

The skeleton was described as imbedded in the silt in a horizontal position, and as this was not likely to be the posture which it would occupy if buried according to Maori custom, and not observing any evidence of a Maori camping ground in the vicinity, I concluded that it must have been deposited here by natural means.

These silts at low levels are generally in a horizontal position, but between the Flagstaff and Cape Wanbrow, they dip to the S.W. 10° to 16°. As raised beaches they extend south along the coast, till within two miles of Kakanui, and all along this coast obscure the Awamoa beds. They fill the lower part of the creek which from south Oamaru reaches the sea between Awamoa Creek and Cape Wanbrow.

In a north-westerly direction they are confined to the higher ground, between Awamoa Creek and Oamaru Creek, and some heavy cuttings on the Oamaru and Moeraki line of railway, near the Waiareka toll-gate, are excavated in them. No fossils are, however, to be seen here. In this direction they extend till they are seen to overlie the Ototara limestone in the low ground near the upper part of Awamoa Creek, and are exposed in the road and railway cuttings along this line.

Similar beds, presumably of the same age as those which contain the moa bones, occur near the township of Teneraki, in the Waiareka Valley, and thence extend south-west some distance in the direction of the Kakanui River. These differ in no respect from the deposits near Oamaru, save that the thin beds of gravel at their base are composed of quartz pebbles derived from the grits in the vicinity.

Older Gravels.

A noticeable feature in all the districts over which my examinations extended is the existence of heavy beds of gravel and sand, generally forming downs and low hills along the western border of the plains, but sometimes where influenced by the underlying rock, covering table lands of considerable extent. They make the Mount Grey and Moeraki Downs in the northern part of Canterbury, and the low hills on the south side of the lower gorge of the Waipara, and probably some of the higher gravel beds skirting the Malvern Hills.

Unless a small patch near Peter's station, on the northern Hinds, should prove to belong to these beds, I have not noticed them between the Rakaia and Rangitata Rivers. South of the Rangi-

Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S., DIRECTOR.

To illustrate Report by A. McKAY. January, 1877.

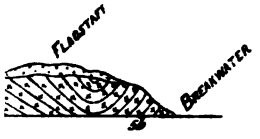
PLAN

OF THE

OAMARU DISTRICT

1. River Gravels, Silts of Oamaru &c.
2. Awamoa & Pareora beds — Lower Miocene
3. Hutchinson Quarry & Mt Brown beds — Upper Eocene
4. Otekaike Limestone
5. Tufas, Volcanic rocks & Greensands — Cretaceo-Tertiary
6. Coal beds, Grits &c.
7. Old Slates &c.

(da)
- Mt Grey to



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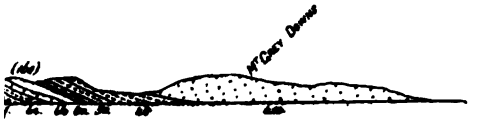
SECTIONS

OAMARU TO WAITAKI



– Mt Grey to Mt Grey Downs

4a. Gravel beds
4b Waerenga beds
5a. Mt Brown beds
5b Hutchinson Quarry beds
6a. Grey marls
6b Oamaru limestone
6d Tufas and Chalk marls
6e. Greensands with Lava flows
6f Reptilian beds
6g. Grits and Sandstones

tata, they again begin near the gorge of the Orari River, and form the downs between Pleasant Valley and the township of Geraldine. Thence they form the low downs between there and the Kokohu, and in like manner sweep round as far as Pleasant Point.

In the valley of the Opihi, they are found considerably further west, and thence strike south-west in the direction of the cave, on the Tongawai River. They are largely developed in the upper Pareora district, and form the ridge of hills separating this river from the Tongawai, near the cave. Thence they fill nearly the whole valley between Mount Nimrod, and the Hunter Hills on the west, and the range through which the Pareora breaks at the lower gorge. Below the gorge of the Pareora, these gravels form the downs on the south side of the valley, and, in this direction, may be found at intervals as far as Waimate, though here they appear to be considerably denuded. South of Waimate, they are largely developed between the Waiho and the Waitaki Rivers, where they appear to form hills attaining a considerable elevation, but as I did not examine this part of the country, other beds may be present. On crossing the Waitaki River and the Papakio Plain, they again appear near the junction of the Waitaki and the Main North Roads, and, from this point, are continuous along the ridge of hills facing the sea, as far as Oamaru, terminating at Hutchinson's quarry, within the boundary of the town.

They are next seen as a ridge of low hills on the left bank of the lower part of Awamoa Creek, separated from the hills forming Oamaru Cape by the creek, which, from Oamaru, flows south, reaching the sea between the mouth of Awamoa Creek and Cape Wanbrow.

A considerable outlier of these beds commences on the left bank of the Kakanui River, not far from the northern boundary of the Totara Estate, and thence striking north, forms a long narrow ridge, which does not appear to cross the Waiareka Valley.

Between the Awamoko and the lower part of the Maraewhenua River, a considerable extent of high table land appears to be covered by gravels which may be doubtfully considered as of the same age as these beds, and also under like conditions, though to a less extent, between the Maraewhenua and the Otekaike.

Except in the case of the Kakanui outlier, these gravels are never seen to overlie other than tertiary rocks, and rarely are seen abutting against the older rocks (when they do it is generally along a line of fault), thus proving that they are but the upper members of a forma-

tion, the lower beds of which usually crop out on their western borders. These underlying beds are fossiliferous at almost every point where they make their appearance, and have been known by various local names, as the Awamoa beds, the Hampden beds, the Pareora beds, etc. To me they appear to be a lower group of the Kanieri series, and equivalent to the Hawke's Bay series, the same which form the Taipo Hills, on the East Coast of Wellington, and as it is impossible to separate them from the Mount Brown beds (the upper group of Captain Hutton's Oamaru formation), these also must be considered as belonging to the same series. These lower beds of the series, in the Waipara, appear as if quite conformable to the grey marls; the lowest beds being a coarse shelly limestone; the higher beds being the gravels and sands of the Mount Grey Downs, with blue or grey fossiliferous sands between. The lower beds, followed from the Waipara in a south-west direction, are cut off at the north-eastern slopes of Mount Grey, as are also the underlying Weka Pass and Saurian beds further to the west. They soon however re-appear, on the south-eastern slopes, crowning a high ridge between the two main branches of the Grey Stream, in the more southerly branch of which the following sequence may be seen :—

1. Gravels forming the greater part of the downs on both banks of the creek. (These have a very considerable thickness, probably 300 or 400 feet).
2. Beds of brown sands with a thin seam of lignite.*
3. Pebble beds with brown or grey sands (fossiliferous), passing into
4. Blue sandy beds with concretions. These lie on
5. Mount Brown limestone, the lowest beds of the series.

The underlying beds have the same strike and dip as these, and unconformity cannot be said to be established here, between the Mount Brown limestones and the grey marls; they strike nearly east and west, dipping south at an angle of 25°, which lessens as the higher beds are reached. At White Rock, and where the same beds cross the Okuku River, the strike is N. 20° E, dip E.S.E., 25° to 30°. In this district there is a great difference in the character of the higher and the lower beds, and between the lower beds at different points. Thus the coarse rubbly often incoherent limestone of Mount Brown, at the White Rock, forms a white stone much used for building purposes in Christchurch. The fossils also differ considerably, at the White Rock Quarries *Echino-*

* This lignite also occurs in the south branch of the Kowai.

derms and large *Pectens* being plentiful, which seem to be entirely absent from the higher and less calcareous beds.

These considerations led me to doubt the propriety of regarding the gravels of the Mount Grey Downs as of the same age as the gravels occurring in the Upper Pareora; that is, assuming that in either locality they form the highest beds in the district belonging to the Hawke's Bay series.

In other districts where the intervening beds are fossiliferous, this is less apparent, and a general mixture of all the different fossils—the larger *Echinoderms* excepted—takes place.

Hence, as there is no reason to suppose that there are in the districts over which my examinations extended two distinct formations of tertiary rocks, each having for its upper beds heavy gravels as above described, and as the section shown along the banks of the Grey Stream exhibits a gradual passage from the gravels into the fossiliferous beds, there can be no doubt but that all the beds are closely related to each other. Unfortunately no collections were made from this locality, as I hoped to pay it a visit on my return which I was not able to do; but as the fossils from the lower gorge of the Waipara belong to the higher part of the Grey Stream section, a comparison of these with the other localities will show their relationship.

In the Kokohu, after having passed the gravels which form the higher beds, brown sands are seen to underlie, which passing into blue sandy beds, here become highly fossiliferous. In the higher part of these beds, the fossils which are in the loose sands exist only as casts; while, in the lower part, they either are exceedingly fragile (with the exception of a few varieties), or are included in concretionary boulders of extreme hardness. Lower in the section the sands have a greenish tinge, and lie, as far as can be made out, conformably upon the calcareous sandstone, which here terminates the cretaceo-tertiary formation. I saw here no traces of the lignite bed which usually separates the fossiliferous beds from the overlying gravels; and this section differs also from the Mount Brown and White Rock sections, in the absence of the lower calcareous member.

By reason of a fault which here crosses the river in a north and south direction, with the down-throw to the west, the section is repeated with the exception of the gravel beds, which are not here present. The stratification is not very clear, and the strike must be determined by that of the underlying calcareous green-sands; the dip

along the junction with the underlying beds may be 25° or even 30°, but this soon lessens to not more than 10°.

The sequence at this point is :—

1. Conglomerates, or gravel beds, forming the easterly part of the downs.
2. Brown sands, passing into the blue sands, with concretions; both the sands and concretions being highly fossiliferous. *Pecten hochstetteri* is found in the highest fossiliferous bed.
3. The sands No. 2, without concretions, and having more of a greenish tint than the higher beds.

Before crossing the Opihi River, one mile below Hornbrook's station, stray fossiliferous boulders belonging to these beds are seen, but the beds are not exposed in section, the rocks *in situ* belonging to the coal series. Between this and the cave, they appear at several points, and in such localities *Pecten hochstetteri* may generally be obtained.

In the upper part of the Pareora River, these beds, especially the higher part of them, are well exposed, both in the White Rock River (a tributary coming in from the south-west) and the main branch of the Pareora itself. Near the junction of the White Rock River (from which the collections were made), the following sequence may be observed :—

1. Heavy beds of gravel and sand, dipping east at low angles, but gradually becoming greater as they are followed westward.
2. Beds of sharp grey and light-coloured sands, underlaid by a seam of lignite.
3. Dirty coloured and brown sands, dipping east at a high angle. Suddenly the beds become horizontal, and the next beds seen are :—
4. Grey sands, with beds of shells, mostly in a fine state of preservation.
5. Dark blue sandy beds, with irregular concretionary masses, with thin streaks of shelly beds in the sands; the concretions are often crowded with shells.

The beds now dip at a low angle to the west, and repeat the section in ascending order, but they are obscured by river alluvium before the higher beds are reached. Near the upper gorge of the Pareora the section is more complete, limestones and the underlying coal beds striking through from this point to Coal Creek, on the Burke's Pass Road. I did not however visit this locality, hoping to observe the

relation to the underlying beds east of the lower gorge of the river, where practically the same beds are repeated, No. 5 being seen as cliffs of blue sandy clays along the river bank, at the southern base of Mount Horrible, but even here, the relation of these beds to the calcareous rocks underlying is not very plain, as between them and the next seen rocks, an intervening space shows either river gravel or *débris* from the volcanic rocks capping Mount Horrible.

In tracing the section from the limestones upwards, a light grey marly sandstone is seen to overlie the calcareous green-sands (Weka Pass stone), but I could not satisfy myself as to its relation either to the underlying or overlying rocks.

At this point, on the south bank of the Pareora, the section is obscured along the junction between the higher beds and the calcareous green-sands, and no fossiliferous beds are seen till fully a mile further down the river, at which point the low hills bordering on the river valley contain large lentil-shaped masses of hard sandstone, full of shells, from which I made a small collection. The beds here strike away to the south-west, following the course of the underlying limestone, and a narrow valley separates the fossiliferous beds from the overlying gravels, which form downs and low hills, reaching the Main South Road near the railway station (St. Andrew's).

Although these beds are largely developed further to the south, between this and Waimate, and between there and the Waitaki, I made no examinations of, nor collections from them. South of the Waitaki, these beds are first seen in the low hills between Lundon Creek and the Papakio Plains, from the southern border of which they are nearly continuous to within two miles of Kakanui Township, occupying the whole coast line, except where recent beds occur which, as raised beaches, form the shore line—Oamaru Cape being an exception; rocks belonging to the underlying cretaceo-tertiary formation forming the south-eastern portion of the hills which make the cape. In describing the different localities whence fossils were collected, the particular bed may be referred to one or other of the following divisions, which include all the rocks observed by me between the upper surface of the Ototara limestone, and the higher fossiliferous beds of the Awamoa :—

1. Tufas and volcanic rocks, as large spherical masses, with the interspaces filled with altered limestone, or as a hard indurated shelly bed.

2. Green-sands, unaltered, full of shells, corals, and spines, of *Echinoderms.**
3. Shell conglomerate, principally *Turritella gigantea.* (Grey sands sometimes part these from the overlying beds).
4. Dark blue or green sandy beds.
5. Blue or yellow coloured sandy beds, with hard bands and irregular concretions.
6. Beds of coarse gravel which always cap these beds whenever the higher part of the section is reached.

Captain Hutton in his report on the "Geology of Otago, 1875," page 57, describing the higher part of this series under the heading "Pareora Formation," says, "South of the Kakanui River, it extends to the Otepopo River." I examined the Otepopo River, along its left bank from the railway crossing to its mouth, and, thence the coast line north to within a short distance of Aorere Point, but saw no rocks which I could refer to an horizon higher than the Ototara limestone, and suspect that it does not occur further south than two miles north of Kakanui township. The lower beds, No. 1, occur near the township of Kakanui as a coarse shelly limestone, scattered through which are pieces of volcanic rock, forming there a little isolated patch close to the road leading to Oamaru. North of this, for a distance of rather more than half a mile, limestones form cliffs along the shore, which are overlaid by the green-sands (2), underlaid by limestone, which on its inland outcrop presents more the character of the Ototara stone, and certainly the tufas underlying the Ototara limestone are found on the coast for the next half-mile north, where the beds strike N. 50° E., with a dip of 35° to the S.E. These are overlaid by tufas and breccia beds, with thin streaks of altered limestone, probably representing beds No. 2, equivalent to the rocks seen near the breakwater at Oamaru; and from this point, the section is obscured by a raised beach rock, appearing at one point only, between there and the S.W. side of Oamaru Cape. This appears as a reef at low water of brown sandstone. Masses of hard grey sandstone are cast ashore by the surf, and these will be seen to represent the middle part of the Awamoa beds, the highest beds being blue sandy clays, seen a quarter mile up the creek. The western boundary of this formation at

* These beds are at Oamaru Cape overlaid by tufas and brecciated volcanic rock, with lava streams, standing at high angles, and interbedded with thin seams of altered limestone; but these beds are very uncertain in their distribution.

Awamoa strikes, from the coast line, nearly N., passing through the quarry reserve, on the south side of the Main Road, near Awamoa railway cutting, and thence as basaltic rocks forming the table land near the Waiareka toll-bar. The main branch of Oamaru Creek may be taken as its western boundary, as far as the Devil's Bridge, where the beds strike east, but shortly again in the eastern branch of the creek resume their N. to S. strike, and thence continue to the southern borders of the Papakio Plain.

The outlier of these rocks, between the Kakanui River and the Upper Waiareka shows them to be quite unconformable to the Ototara limestone, and the tufas and green-sands underlying, as the limestone is absent, and the conglomerates and blue clay seem there to lie on the tufas and basaltic rocks, which are the northern continuation of the Mount Charles rocks, at Otepopo. This conclusion is quite irresistible if we consider the upper part of the valley of the Waiareka as due to denudation and not to a fault, which latter it could not well be.

On the north side of the Maraewhenua, between that river and the Otekaike River, is a series of table-topped hills, the upper beds of which are coarse gravels, which may be either old river gravels or the higher beds of this formation, underlaid by brown or light-coloured sands; in the lower part of which lenticular masses and beds of hard sandstone occur, full of fossils, which may be referred to this formation, though being perfectly conformable to the underlying Ototara limestone, they may also be the higher beds of that formation (cretaceo-tertiary). The gravels of these hills cover the table lands on the south side of the Maraewhenua River as well, and the fossiliferous beds underlying will probably be found in the isolated hills behind McMasters' station, at the junction of the Maraewhenua.

The green-sands and calcareous beds, and lava streams, and breccia beds, constituting the lower members of this formation, I shall be able to show are quite unconformable to the underlying cretaceo-tertiary formation. Beginning with the evidence to be found in Cape Oamaru, the breccia beds and calcareous green-sands are clearly seen to lie on the tufas which belong to the cretaceo-tertiary formation, round which the breccia beds, or volcanic rock and calcareous green-sands of Hutchinson's quarry, wrap in such a manner as to be the most conclusive proof of unconformity. At the breakwater, the volcanic rocks, with thin seams of altered limestone, strike S. 15° W.; on the coast, south-east side of Flagstaff Hill, the strike of the green-sands of

Hutchinson's quarry is E.—W.; while on the S.W. side of the cape the strike is N.W., and the dip S.W. While these beds thus vary in their strike, the tufas on which they lie strike at the point of junction E.—W., and at Cape Wanbrow, N. 25° E., dipping at a considerable angle to the S.S.E. From the S.W. side of the cape, the calcareous green-sands strike (in their outcrop along the flanks of the hills) in the direction of Oamaru, and thereby enclose on three sides the central mass of underlying tufas. The Ototara limestone is absent on the N.E. side of the cape, under Flagstaff Hill, and is doubtfully present on the S.W. side, although a limestone resembling it in character is seen under the Hutchinson's quarry beds. Admitting this to be Ototara limestone, it but the more conclusively proves the unconformity, although here it appears to conformably underlie the Hutchinson's quarry beds. Plan and section will however show this better than any written description. Near the point where the Main South Road crosses the Awamoa Creek, solid flows of volcanic rock overlie the Ototara limestone. At Hutchinson's quarry, the characteristic bed of calcareous green-sands is underlaid by water-worn conglomerate of these same volcanic rocks, thus showing that the lava streams had suffered denudation before the deposition of the said green-sands. At the south end of the Awamoa Beach, tufas underlying the Ototara limestones are overlaid by the breccia beds of Cape Oamaru, with thin streaks of altered limestone, but none of the higher beds are seen, owing to the erosion of the beds by the sea, and the existence of a raised beach, which obscures the softer and low-lying beds in the valley of the Awamoa Creek.

Between the Kakanui River and the upper part of the Waiareka Creek, conglomerates belonging to the higher beds of the rocks last described, and the blue clays of the Awamoa Creek, are reported to occur both by Captain Hutton and Mr. Traill, in such a position that they cannot but be unconformable to the beds which underlie them. To the west of the ridge of conglomerates, I saw traces of a calcareous green-sand, which might be the Hutchinson's quarry beds, but not finding fossils, I cannot prove this, but as these elsewhere underlie quite conformably the Awamoa beds, and ample collections prove them to be but members of the same formation, the presence of even the upper members in this position is sufficient to show the relations of the whole. The lower beds of this formation are not developed in a typical manner. In the Pareora or the Kokohu, and at Mount Grey, and in the Waipara,

being apparently conformable, the evidence there is of no value in support of the view I have taken up.

Grey Marls.

This division of the cretaceo-tertiary formation is not present throughout the greater part of the district, either in southern Canterbury or northern Otago, not having been seen further south than the Grey Stream White Rock quarries. In the Waipara, it forms an important member of the section there displayed on the western slope of Mount Brown, separating the Mount Brown limestone from the Weka Pass calcareous green-sands (Ototara limestone), the beds there having a thickness of not less than 200 feet. In the Grey Stream section, the grey marls are not more than 50 feet thick, and south of this seem to be absent.

In the Kokohu section, both the grey marls and the Mount Brown beds are absent; the Pareora beds lying as far as can be seen on the Ototara limestone.

At the Maraewhenua, the beds which there conformably overlie the Ototara limestone may be the representatives of the grey marls, but as both the matrix and the fossils are unlike what these beds generally exhibit, this is uncertain.

Near Oamaru, the horizon of these rocks is occupied by volcanic rocks, separating the Ototara limestone from the Mount Brown beds (Hutchinson's quarry beds), and although sometimes accompanied by breccias and tufas, they are unfossiliferous.

The only place in the southern districts where rocks at all resembling these made their appearance, was in the gorge of the Pareora, at the southern base of Mount Horrible, where the beds intervening between the Ototara limestone and the Pareora beds may be the representatives of them.

Ototara Limestone (Weka Pass Stone).

This rock, so strongly developed in the Waipara and Weka Pass district, in the Grey Stream and at White Rock appears only as a bed of slightly calcareous green-sand. In the Grey Stream fossils in this rock are plentiful, and are the same as where the rock is much more calcareous, further to the north. At White Rock, this rock has passed completely into a green-sand, which might be confounded with the green-sands of a lower horizon (overlying the Saurian beds).

In the Kokohu, this rock has a thickness of at least 100 feet, and presents quite the same character that it does at the Weka Pass and in the Waipara. Fossils are not very plentiful, and of these the number of

species are few; so that, but for the mineral character of the rock, and its gradual passage into the well-known underlying Amuri limestone, it might, as has been contended, be considered to belong to a higher horizon than the Ototara limestone; the Mount Brown beds being absent between it and the Pareora formation, as developed in Kokohu.

From the Kokohu these rocks strike south to the Opihi River, some distance above Pleasant Point, and thence on the north side of the river for some distance above Parnell's station.

Along the eastern slopes of the range, dividing the Opihi and Tongawai Rivers, it is traceable as far as the cave on the latter river; on the south side of which it is seen lying on the old rocks, which from this point form the range as far as the lower gorge of the Pareora. The Ototara limestone lying on its eastern slope—but here separated from the old rock by the intervention of the coal series—which, near the Gorge, lying at a low angle, causes the limestone to cross the valley and appear on the south-western slopes of Mount Horrible, whence, crossing near the junction of Little River, it forms the higher part and western slope of the range south of that river, from which point I did not trace it further south. On the south side of the Pareora, in the gorge, near the water level, the old rock is seen; but the range to the south is composed of rocks of the coal series, capped by a thick bed of Ototara limestone, which extends for some miles to the S.W.

Near the Upper Pareora gorge, this rock is probably present, underlying the Pareora beds. I did not, however, see it here nor south of the last-mentioned locality until the Waitaki is crossed, up the valley of which it covers a considerable extent of country, between the Awamoko Creek and the Otekaike River. The area covered by it in this district is of triangular form, its greatest width being between Black Point and the upper part of the Waiareka Valley, and thence gradually narrowing till it terminates on the south side of the Otekaike River, near the main road.

Throughout this district, the beds are nearly flat, except near the northern end, where they have a slight dip to the S.E. The thickness of the beds is variable, the passage being gradual into the overlying beds, but 100 feet may be said to be the greatest thickness; the good stone at the base seldom exceeding 50 feet. The rock, which in its better parts resembles the Oamaru stone, although considerably harder, in its lower part becomes highly charged with green-sand, and richly fossiliferous, and from this horizon the bulk of the collection made by

me was obtained. These contain, amongst others, a *Lima*, common in the Cobden limestone and in the white limestone of Waihola Gorge.

South of the Awamoko, the Ototara limestone is first seen S.E. of Big Hill, on the borders of Papakio Plain, whence it runs nearly W. across the upper part of the Oamaru Creek to the Waiareka Valley, two miles above the railway crossing. Thence down the east side of the creek, forming high escarpments, save where broken through by small creeks flowing west into the Waiareka. The first of these is opposite the township of Teneraki; the second, Cave Valley, through which the railway passes into the Waiareka; the third, on the main line of road south, near the Totara station, a mile below which it leaves the banks of the creek, and strikes S.E. to the coast line, one and a half miles north of the Kakanui. It covers the country north of the main road, and east of the scarp just described, as far as the Devil's Bridge, in a northerly direction, and Oamaru Creek on the east, passing under volcanic rocks, in Awamoa Creek, near the Waiareka toll-bar.

An outcrop of it strikes up the left branch of the Awamoa Creek, and crosses Loudon Creek, there joining the same beds coming east from the Waiareka.

A small patch of this limestone is seen on the south side of Oamaru Cape, and traces of it are to be met with on the coast, between the Kakanui and Otepopo Rivers. From the Kakanui River, near the railway crossing, it extends up the river as far as the boundary of the Totara Estate, and these, except it be a small outlier on the north bank of Island Stream, may be said to be all the outcrops in the district.

Chalk Marls and Amuri Limestone.

These rocks have been so often described in the Waipara and Weka Pass districts that, in the absence of new facts, it seems unnecessary to describe them here. In the Grey Stream, on the south side of Mount Grey, fragments appear in the gravels of the water course; but in the section exposed in its S.W. branch, this rock does not appear to be present, grey sands with concretions underlying the Weka Pass calcareous greensands; nor is it again seen along the borders of the plains till the Kokohu is reached * where the calcareous greensands gradually pass into chalk marls, which in that section are clearly seen to overlie fossiliferous green-sands. In the lower gorge of the Pareora, they are

* It may, however, be found at Castle Rock, on the West Coast Road; at Red Cliff, on the Rakaia; and on the banks of the Northern Hinds, in which place it is strangely developed as a chalk marl, overlying green-sands and coal seams.

typically developed as a chalky limestone underlying the calcareous green-sands that crown the range on the south side of the gorge, and east of the gorge at the junction of Little River. Under the limestones at Maraewhenua, this horizon is represented by chalky and pure green-sands, and along the scarp bounding the lower and middle part of the Waiareka Valley by grey tufas and beds of chalk, composed entirely of Foraminifer shells. Flints are plentiful in this locality, the specimens obtained being perfectly indistinguishable from the chalk flints of England; the flints are black, the weathered surface of the stone being white for a thickness of half an inch. One and a half miles inland of the mouth of the Otepopo River, marly green-sands containing Foraminifera and other shells, besides plant remains, may be doubtfully referred to this or a lower horizon; certainly not to a higher, as they are overlaid by the lava streams of Mount Charles, and, as I would refer the whole of the tufas and lava streams underlying the Ototara limestone, and overlying the lower green-sands, next to be described, to the Amuri limestone, chalk marls and teredo limestone of the Amuri Bluff section, the fossiliferous green-sands above-mentioned would occupy the lower horizon of this group, although the line could not always be drawn between these and the underlying green-sands which overlie the coal grits.

Concretionary Green-sands.

These beds are an easily-determined horizon throughout the whole district over which my examinations extended, being equally apparent in the Waipara, Grey Stream, White Rock, south of Mount Grey, and in the Kokohu, in which latter locality they are highly fossiliferous. Important shells being obtained here, serve to connect this horizon with the Nine-Mile Bluff and Ten-mile of the Greymouth coalfield, the importance of which can hardly be over-estimated.

In the lower gorge of the Pareora, these beds are represented by sharp grey quartzose sand, in which sharks' teeth are of very common occurrence; and a bed of fossiliferous sandstone, the position of which as regards the other beds I could not clearly make out.

In the Waitaki Valley, these green-sands are often found lying at no great distance above the coal, their lower part being interbedded with yellow coloured quartzose sands; the grits overlying the coal being in a great measure absent. At the Maraewhenua gold workings they (the green-sands) closely overlie the gold drifts, and in one or two claims the lower bed full of sharks' teeth is worked for gold. This particular bed

in the Maraewhenua section is overlaid by green-sands, which in turn are overlaid by sandstone full of marine shells; of this there can be no doubt, as the clearest possible sections show that it is so. Green-sands overlie the coal grit in various places, from Big Hill, across the Waiareka Valley, to the Kakanui River, thence along the slopes of the range to Otepopo, where they are well seen in the railway-cutting under the southern slopes of Mount Charles. In the Kakanui River, west of Cave Valley, the green-sands are plentifully interbedded with large irregular masses of carbonate of iron.

Saurian Beds and Coal Seams.—In the Waipara the Saurian beds are underlaid by the *Ostrea* bed, which in the Malvern Hills overlies the coal seams. This in turn is underlaid by coaly shales and sandy clays, which, downwards, pass into conglomerates, which in the banks of M'Kay's Creek (the tributary examined) present a very recent appearance. Occasional beds of shale, with large boulders of ironstone with Dicotyledonous leaves, occur in this part of the section; the lowest bed being a coarse conglomerate, resting on the underlying rock unconformably.

At White Rock, green-sands probably represent the Saurian beds, and are underlaid by rusty-coloured sandstones, which probably represent the lowest beds in the Waipara section. I have not ascertained the existence of coal in this neighbourhood, although I have heard reports of its existence further south on the flanks of Mount Thomas, and it is present at Glentui, near the Ashley Gorge. In the Kokohu, the Saurian beds are represented by yellowish grey sands of inconsiderable thickness, beneath which occur the coal seams, which are underlaid by red grits and breccia beds. In the section shown, but on the south side of the river, fire-clays of a snow-white colour, and very fine quality are associated with the coal. Here, and south of this, the Saurian beds are not to be distinguished from the coal beds, on the one hand, or the green-sands which overlie on the other; they having, in fact, thinned out. Coal is found at several points on the banks of the Kokohu River, but in rather thin seams, and of inferior quality. Where first prospected near the junction of the creek, coming from the Kokohu Bush, the beds dip at high angles to the east, and the workings have the disadvantage of being situate in low and wet grounds, so that at this point the seams cannot at present prove remunerative. Fully a mile higher up this same creek, the strata dip at a low angle to the east, and here, free from the water which proves so troublesome in the lower part of the

creek, a coal mine has been opened, which, were the seam thicker and of better quality, might be worked with advantage, but so far as yet opened up the coal proves to be so shaly as to be of little value; the quantity of incombustible matter being very great, while the thickness of the seam does not exceed three feet. Nevertheless, as there is a considerable extent of country between this point and the Opihi River, the thickness and quality may improve in this direction, but I have no data for this assumption. I did not again see any of the coal-bearing series till the lower gorge of the Pareora was reached, where, although the associated rocks appear, lying between the old rock and the limestone forming the range on the south side of the river, I observed no coal. The rocks are grey quartzose sands, with occasional beds of small pebbles, composed of quartz, and often contain sharks' teeth. A shell bed occurs in contact with these sands, but as it presented some appearance of unconformity, this may belong to a younger series. Coal is said to occur some distance above the junction of Little River with the Pareora, opposite Mount Horrible. South of Oamaru, coal is found on the ranges behind Otepopo, associated with beds of shale and quartzose conglomerate, which, striking north, cross into the Waiareka Valley, and thence to Big Hill, where two coal mines are at present being worked. On the higher grounds, and on the top of Big Hill, the strata dip at low angles; but west of a ridge of old schistose rock, which, coming from the north, here passes under the coal-bearing series, the latter dips at high angles to the west, 70° to 80°, and in some places almost vertical, but this high dip soon falls to moderate angles, and a considerable extent of country is covered by quartz grit between the Waiareka and the Awamoko Creek to the north. At Black Point, on the Waitaki River, four miles below the Maraewhenua, the coal beds are of inconsiderable thickness, but of great interest from the fact of their here being richly fossiliferous; and in their lowest beds being composed of coarse conglomerates of sandstone and other rocks, overlaid by the usual quartz grits. The coal is here represented by a carbonaceous shale, overlaid by white fire-clays, with numerous indistinct plant impressions, which pass into a mixture of yellow and green-sands with hard concretions, full of fossil shells, which are, in turn, overlaid by green-sands, sometimes marly; and eventually the whole is overlaid by the Maraewhenua limestone, forming the table-lands to the west. In the upper part of the Awamoko Creek, the coal beds are not yet known to be present; but a considerable extent of country near the

Maraewhenua gold-workings is covered by the coal grits and the overlying green-sands, which, striking across the Maraewhenua River, reach as far as the Otakaika River, west of the limestone table-lands. The grits in this latter district are of great interest, as they form the matrix from which most of the gold on this field has been obtained; all the claims which I examined being opened in the grit, and not a few of them directly overlaid by fossiliferous green-sands and sandy calcareous beds, full of marine shells. From what I could learn, paying gold-workings have not been found in this district in any other deposit than this quartz grit, which, dipping away to the east, is overlaid by a thick bed of columnar basalt, followed by the representatives of the green-sands, and again by the Maraewhenua limestones.

The district lying between the Otakaika and the coal outcrop, at Big Gully, I did not examine, but an examination of the collections made in this district by Mr. Charles Traill, now in the Colonial Museum, clearly shows that the equivalent beds of Hutchinson's quarry, Oamaru, and even higher beds, assume the character of a calcareous sandstone—at Otakaika and at Big Gully, of a tufaceous green-sand.

Volcanic Rocks.

Dolerites of Mount Charles.—These rocks, which have already been alluded to in that portion of this report descriptive of the beds underlying the Ototara limestone and the green-sands overlying the coal beds, in order clearly to show their relation to the Ototara limestone, will here require a more detailed description. This is the more necessary, as Captain Hutton refers the Mount Charles Volcanic Rocks to the Miocene period, and considers them as forming part of his Pareora formation. As seen in the section, between Herbert and the crossing of the Otepopo River, a thick bed of these rocks overlies the higher beds of the green-sands overlying the coal beds. *Tufas* and marly beds overlie, but in the Otepopo River, the section is obscured till within one and a half miles of the river mouth, when the dolerites are seen on the two flanks of an anticline; the higher beds of the green-sands appearing between the dolerites on the east side, being seen to be followed by *Tufas* as far as the mouth of the river; while between there and Mount Charles, though not seen at the same point more to the north, they are seen to overlie the dolerites, and cover the country between Mount Charles and the Kakanui River, of which many interesting sections are to be seen in the cuttings along the railway line. On the east bank of the Kakanui, near the Kakanui flourmill, the *Tufas* which overlie the

harder flaws of volcanic rock are overlaid by a considerable outlier of Ototara limestone, and here we get the first decisive evidence as to the age of the dolerites of Mount Charles, which shows them to be older than the Ototara limestone. The dolerites may be seen at many points, and both in the upper part of the Waiareka Valley, and at all such places, are interstratified with the higher beds of the green-sands, and in all cases overlaid by the *Tufas* or tufaceous sandstone (these rocks being described as sandstones where they occur in the beds forming Cape Wanbrow, near Oamaru); and traced to the N.E. they are seen in the upper part of Oamaru Creek to distinctly underlie the Ototara limestone. The same rocks are seen to underlie the Maraewhenua limestone, five miles above its junction with the Waitaki, and they there overlie the green-sands and coal grits as at Mount Charles and in the Otepopo River.

A younger series of volcanic rocks are found developed to a considerable extent in the neighbourhood of the town of Oamaru, partly above, and partly below the limestones and calcareous green-sands of Hutchinson's quarry, as seen in the section along the coast, from the breakwater to Cape Wanbrow. In some places these volcanic rocks, as lava streams, lie hard upon the Ototara limestone, as near the Waiareka toll bar, on the Awamoa Creek; the lower tertiary rocks being often much altered when in contact with these rocks. North of Oamaru, these rocks are last seen in the water-shed between Oamaru and Lundon Creeks. At Timaru, Pareora and the Kokohu, volcanic rocks, as lava streams, are found associated with the Pareora beds; their occurrence in Mount Horrible, where they are best seen, has been fully described by Dr. Haast.

REPORT ON THE COUNTRY BETWEEN MASTERTON AND NAPIER.

BY ALEXANDER McKAY.

28th February, 1877.

NARRATIVE.

ON the evening of the 20th January I left Wellington by train for the Upper Hutt, and next day walked along the railway line, examining the sections seen in the cuttings, as far as the Pakuratahi Station. On the 22nd walked over the Rimutaka Saddle, taking the coach from the eastern foot of the range, for Masterton. On 23rd January arrived at Dorset's accommodation house, where stormy weather detained me till the 25th, on which day I reached the Scandinavian settlement on the Mangatainoko River; and on the 26th arrived at the Manawatu Gorge. Here I made different examinations, and collected till the 1st of February; bad weather causing much detention.

On the 1st February I collected from the serpentinous slates and older rocks of the Manawatu Gorge, and examined the lower part of the Pahanginga River; and next day followed the old track, crossing the range to the north of the gorge some distance down the eastern watershed, where the difficulty of finding my way and the threatening state of the weather compelled my return by the same route. Bad weather again set in on the 3rd, and compelled me to relinquish the idea of making a collection from the beds lying between the Mangatainoko and Mokango Rivers, so I took coach for the northern end of the Seventy-Mile Bush, intending to stop at any place which seemed to promise any results. As I observed nothing of particular interest until within ten miles of Norsewood, I proceeded to the next stage (Takapau), where exceptionally bad weather prevented my doing any work till the 11th, when I went back through the bush some twelve or fourteen miles to examine the different sections exposed along the road; the country otherwise being perfectly impassable, on account of the floods due to the late rains.

On the 12th February, finding nothing to detain me further, and it being impossible to penetrate the country in the direction of the Ruahine Range, I examined the hills bounding the south-eastern part of the Ruataniwha Plains, and made a collection from the limestone and clays which here overlie the limestone. On the 13th, following

the limestone range, I reached Waipukurau, where I waited for further instructions; at the same time examining the neighbourhood. On the 15th, I crossed to Waipawa, where I remained till the 20th February, collecting from the surrounding district. On the 21st, I examined the banks of the Mangaonuku River, along the northern boundary of the Ruataniwha Plains, and made a small collection from the limestone range to the east.

On the 22nd, I left Hampden for Kereru, where I arrived the same evening, collecting there, and examining the neighbourhood, till the 3rd of March, when I left for the Ngaruroro Gorge, whence, as the weather proved very unsettled, I did not go further west, but, after staying till the 5th March, followed down the river to Shrimpton's station, on the Kikowero Creek, where I stayed collecting till the 9th March, when I left for Taradale, by way of Okawa Lake, and crossed the Tutaekuri River, a few miles above Puketapu.

On the 10th of March, I went to Napier, and there collected till the afternoon of the 13th, when I travelled by rail to Pakipaki; and the next day examined the country west of the limestone range, striking south from that place. On the 15th, from Mason's station, I followed down the Maraekakahu, to its junction with the Ngaruroro River; thence by the main road to Hastings, returning to Napier the same evening, which I left on the following day; arriving in Wellington on the 17th February, after an absence of 57 days.

GEOLOGY.

1. *Rimutaka Series. Altered rocks of the Manawatu Gorge, and the Ruahine Range.*—These rocks, the oldest which came under my observation, in general appearance resemble the rocks of the Rimutaka Range, between Pakuratahi and Featherston; dark coloured shaly slates and fine-grained indurated sandstones being common throughout. But more noticeable, as a common feature, are red coloured slates and quartz, which seem to be present in every part of the range, from Cook Strait to the gorge of the Ngaruroro River, west of Napier. In the Manawatu Gorge, the rocks are more or less serpentinous throughout the greater part of the section; the dark blue sandstones and slates being confined to the upper end of the gorge, where they appear to underlie the serpentines. A syncline occurs at a point about two-thirds up the gorge; the highest rocks of which are serpentines, which shortly change from a westerly to an easterly dip, and continue to dip in that direction, but without bringing to the surface the

slates and sandstones of the upper end of the gorge; till, on the western flanks of the range, they are covered by younger beds. The strike of these beds varies, but is usually in N.—S. direction, the greatest deviation being at the east end of the Manawatu Bridge, where the strike is E.—W., with a dip to the north of 45°. This is nearly at right angles to the general strike, and as the rocks differ in character from those further down the gorge, it might be supposed that they were unconformable to the serpentines; but, in the road cuttings, three-quarters of a mile down the gorge from the bridge, these sand stones and slates are seen to pass under the serpentines, a little above the first sharp turn in the road. The fact that they do not again make their appearance further down the gorge, I attribute to one or more faults, as a kind of sequence is in the serpentines observed to repeat itself.

I collected from the middle and lower part of the rocks of the gorge, in addition to ordinary rock specimens, iron ores, as hematite and specular iron ore; calc spar, which, occurring in serpentines, has been mistaken for quartz; and compact limestone, as concretions, occurs also in the serpentines. I had no opportunity of again examining these rocks till I reached the northern end of the Ruahine Range, where, behind the Wakarere Range, the red slates and associated strata are seen, striking as belts parallel to the range across the shingle slips.

In the lower part of the Ngaruroro Gorge, the rocks so closely resemble the serpentinous rocks of the Manawatu Gorge, that to say they are the same is a sufficient description.

2. *Wairoa Series.*—These rocks are presumably unconformable to the next to be described, and which I shall regard as one series, though I should not be surprised if they do not prove of the same age; but presenting, as they do, the same general characters, it may be as well to speak of them as such for the present. As no recognisable fossils have as yet been obtained from these rocks, there is some difficulty as to their classification,—whether they are old, secondary, or young Palæozoic being uncertain.

Wherever opportunities of observation present themselves, these rocks are found to be decomposed to a great depth beneath the surface; the rocks consisting of coarse sandstones and crumbling shales, often containing broken plant remains. Near the Upper Hutt railway station, where a heavy cutting passes through these rocks, they are decomposed to a depth of nearly 50 feet from the surface. They here

consist of these alternations of shales and sandstones, and extend along the line as far as the Mungaroa Bridge. In crossing the Rimutaka, and going north, I saw nothing which could be regarded as of the same age, till the water-shed between the Ruamahunga and the Manawatu, in the Forty-Mile Bush, was reached; and here is a spur range from the Tararua Mountains, which, from the highest peaks of the same, runs east and joins the southerly continuation of the Puketoi Range. The rocks, at the point where the road from Masterton to Napier crosses this spur, are hard grey sandstone, with rusty coloured shales, interbedded with igneous rocks. The strike of the beds is N.E., dip to the S.E. at a considerable angle, but on account of the numerous joints which traverse the rock, bearings are difficult to obtain. The older rocks of this range probably strike more to the N.E., than those of the water-shed between the Manawatu and the Wairarapa Plains; the eastern part of which water-shed will, I expect, be found to be on a limestone country; the older rocks most probably terminating on the west side of the Tiraumea River, although it is possible that they may not extend so far, but may terminate on the eastern side of the valley, entering into the structure of the Puketoi Range. That there is some probability of their doing so, is evidenced by the position in which they were next observed by me at the northern termination of the Seventy-Mile Bush, east side, the ranges here being a northern continuation of the Puketoi Range. Here, on Johnston's run, between the Porangahau Creek and the Maharaekeke River, are a series of conical hills, rising 600 feet above the plain; and the rocks of which, striking to the south, form the cove of the range forming the water-shed between the Upper Manawatu and the rivers running to the East Coast. The rocks consist of sandstones and brown sandy shales of the usual character of these rocks; decomposing very readily; strike and dip uncertain, being very difficult to make out. These rocks are of some interest, as away from the skirts of the Ruahine Range, no rocks of equal age have hitherto been observed in the southern part of Hawke Bay; and further to the south, they evidently are the rocks upon which the young secondary rocks lie, though here no such junction is to be observed; tertiary limestones appearing both to the east and west of them; neither in the same line of strike are they to be observed further north, young secondary rocks forming the framework, on which the tertiary beds there repose.

Rocks of this age, however, appear to skirt a considerable extent of the northern part of the Ruahine Range, though in the country to the

west of Norsewood the difficulty of getting through the bush is such that I had to content myself with the evidence I could collect in the streams and near the main line of road. From these sources of information, I gathered sufficient to convince me that rocks younger than those at the Manawatu Gorge have flanked the main range, consisting of coarse sandstones, conglomerates, and sandy shales; in some of which sandstones contained in the superficial gravels near Norsewood, I observed broken plant remains, but, as usual, no recognisable forms. I did not again have an opportunity of seeing these rocks till I reached the Wakarere Range, west of Kereru, where they are seen extending between the Waipawa and Ngaruroro Rivers, nearly continuously.

This range, the higher peaks of which are fully 3,000 feet above sea level, at once arrests the eye even at a great distance, on account of its rugged barren appearance; most of the higher parts of the range being nothing but shifting shingle, or bare and rugged rocks; the whole finely exemplifying the character of the beds of which it is composed. The southern part of the range presents a series of rugged peaks, between which no available pass at a moderate elevation is to be found; but near the northern end, behind Duff's homestead, the range is traversed by a deep valley; the saddle leading into the low country, between the Wakarere and the Ruahine ranges, being relatively very low; but immediately on the north side of this valley, the range again rises to nearly its normal height, and then slopes away in long spurs to the north, which, from their gradual fall and nearly equal height, when seen from a distance, convey the idea of their being the original surface of a plane of denudation, though now deeply cut into by a number of very rugged gullies. A closer examination shows that this is the actual case, for scattered over these spurs are small outliers and isolated patches of tertiary rocks, such as shell limestones; and these attain nearly as great a height as the spurs with the sloping character above alluded to.

The strike of the rocks, though somewhat irregular, is about N. 20° E., the dip on the eastern flank of the range being west, but soon changing to the eastwards; the great mass of the rocks forming the range is found to dip at high angles 60° to 80° in that direction. A variety of rocks are to be found in the range, but coarse sandstones and fine grained conglomerates, with blue slaty shales (which latter weather very freely and form everywhere large shingle slips), are the predominating rocks. Besides these, there are argillaceous limestones, occurring as thin beds, between the sandstones, and forming nests and irregular bands in

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[illegible]—hooks occasionally green sandstones. In all of these rocks [illegible] and carbonised plant remains are plentifully distributed, but the [illegible] search failed to produce a single impression that could be [illegible] as a definite organism; neither the boulders in the creeks nor the shaly beds on the hills yielding satisfactory results.

These rocks are not present in the lower part of the Ngaruroro Gorge, the older serpentinous rocks there directly underlying the tertiary beds: but in the shingle of the river bed such rocks are seen sometimes with a considerable amount of carbonaceous matter in them, though never deserving the name of coal. I therefore am inclined to think that they will yet be found on the western flanks of the Ruahine Range and its northern continuation of the Kaweka Range.

YOUNG SECONDARY ROCKS.

These, in the district over which I passed, are confined to a comparatively small area, commencing near Waipukurau and terminating a little north of Karori. They are overlaid to the west by the tertiary limestones, forming the eastern boundary of the Ruataniwha Plains; and to the south-east they extend uninterruptedly, by way of the Porangahau River, as far as Cape Turnagain; but my examinations of these rocks did not, on this occasion, extend beyond the Tutaekuri, my object being to trace them in a westerly direction, if possible. This I entirely failed to do, further than the limits just named; nor could any of the lower members of the series be discovered in this direction.

Beginning near Karori, on the Main South Road from Napier, they form to the west of the road a range of hills of considerable elevation, having smooth regular outlines, which, as a range, terminates on the north side of the Tukituki, at Waipukurau; the limestones on its western flank then, in their continuation south, constituting the range. Near Waipawa, this formation forms an undulating country of low hills; which, beyond the Waipawa Bush, forms a range of hills of greater elevation. Over the whole of this country, extending in a north and south direction about fifteen miles, and in an east and west direction about ten miles, a remarkable uniformity in the character of the rock prevails—chalk marls almost exclusively occupying the whole area—at one or two points, black bituminous marls, full of scales of mica, make their appearance. On the road leading from Waipawa to Hampden, near the junction with the tertiary limestones, they are nearly flat, the dip being slightly to the west; but, on the south side of the Waipawa River, they dip at a higher angle to the east; and between this and three

miles down the river, from Waipawa, several changes in the dip take place. At the lower or east end of the Waipawa Bush, the strike is N. 20° E., with an easterly dip of 70°; half a mile further down the river, they dip to the west, the strike being nearly the same. Fossils in these rocks are very scarce, and mostly consist of Foraminifera, fish scales, and indistinct plant remains.

What strikes one as remarkable is this:—That dipping, as they often do, at high angles, none of the lower beds of the series seem to be exposed in the district; but the reason may be that the beds change their dip oftener than I was able to make out. These rocks are not again seen in the southern part of Hawke Bay Provincial District, west of the Tukituki River.*

Tertiary Beds.

Hitherto the tertiary group of strata, known as the Hawke Bay series, had been understood by me to consist of a thick bed of shell limestone, passing into a series of blue, sandy, or marly clays; the typical localities in the North Island being Scinde Island (Napier), Cape Kidnappers, and Castle Point, on the east coast of Wellington; from which latter place, and from the Taueru River, near Masterton, in the Wairarapa Valley, considerable collections have been made on a former occasion. No unconformity has as yet been made out between the higher and lower beds of the section which embraces the Taipo Hills on the east, and the limestone range bounding the Wairarapa Valley on the west. The fossils from the Taipo Hills and the Maungapakeha Valley, are by Captain Hutton considered to belong to his Ahuriri formation. I may preface my remarks under this heading, by saying that I totally failed throughout the district examined by me on this occasion to discover any beds which I could refer to this division of the Ahuriri formation of Hutton; although further on in this report, abundant evidence will be produced, showing that the beds immediately underlying the limestones (calcareous sands) rest upon the older rocks without the intervention of the Taipo beds, which, unless the upper beds overlap in a most remarkable manner, must have shown somewhere along the different scarps and sections exposed.

* For a fuller description of these and their associated rocks, see Dr. Hector's Report on the Poverty Bay Oilspring Rocks, and the Waiapu and East Cape District; also, report by A. McKay, on the country between Cape Kidnappers and Turnagain.—*Geological Report*, 1873-74.

From Masterton, north to the Ruamahunga River, the whole country is formed of an alluvial plain; but at the point where the road to Napier crosses the river, light blue marly clays begin to show in the banks, and to form a series of low hills and downs on the north side of the river. Near the Scandinavian Camp at the entrance to the Forty Mile Bush, the hills to the north-west are capped by limestone, which reaches the level of the lower ground near Dorset's accomodation house. Looking westward, before entering the bush, the limestones seemingly overlaid by younger rocks, appear to flank the range to the south. At a point reached about five miles after entering the bush, the limestones are seen for the last time on this side of the saddle. At the point where it crosses the road in a S.W. and N.E. direction, it dips to the S.E. at a considerable angle; underneath it lie brown or blue sands, passing into blue marly clay, which has a splintery columnar structure, and is interbedded with several layers of cement stone. No other rocks crop out from beneath these, between the entrance to the bush and the saddle; and no coal has been observed in the various road cuttings, nor picked up in the creeks. On the north side of the saddle, the splintery marly clays are the first rocks seen belonging to this series; but further on, lying on the flanks of the range, and exposed in the side cuttings of the road, are beds of brown and greyish blue sands; which are further on overlaid by the splintery clays, which, with some alternations of sandy beds and beds of cement stone, cover a great extent of country in the direction of the Manawatu; having in the low grounds a strike varying between S. and S. 30° W., with a dip of 20° W. The beds throughout this district seem to be without fossils, although to appearance one might expect them in abundance. Beyond Mellemskoi, the country along the Mangatinoko River becomes very flat, and but five exposures of rock are to be seen for the first ten miles; but where opportunities of observation present themselves, the rocks are of the same uniform character, dipping away to the N.W. On the crossing of the Mangatinoko River, shell limestones and well rounded gravels interbedded make their appearance in a high terrace striking away to the north; perfect shells in the former being comparatively rare. Leaving this terrace range, the country is again flat till the last crossing of the Mangatinoko is reached, where on the west bank, three miles from the Manawatu crossing, high terraces are seen covered by water-worn gravels, and underlaid by brown sands and blue clays, which are probably unconformable to each other; the clays seemingly overlying the shell

limestones and gravels further to the east. These high terraces extend some distance south, and in a westerly direction from the banks of the Mohongo River; west of which river, on the rugged slopes of the Tararua Range, the limestones striking south from the Manawatu Gorge, will probably be found with a comparatively small expansion of the underlying clay marls (as exemplified at the Manawatu Gorge). Beyond a certain point, however, that is, beyond the outcrop of the limestones coming from the east up to the range forming the water-shed as far as the southern part of the Forty Mile Bush, the clays, here of very considerable thickness, will cover the whole country.

After passing the high terraces, three miles to the south of the Manawatu crossing, the country is nearly flat, and covered with river gravels, which extend through Woodville till within little better than a mile of the bridge at the gorge of the Manawatu, where the limestones as calcareous sands again appear, underlaid by conglomerates and blue sandy beds, which have an inconsiderable thickness, being shortly underlaid by the old slates and sandstones of the upper part of the gorge. Crossing the river at this point, the limestones are seen striking south, and probably are bounded on the south in the manner described above. To the north, along the flanks of the Ruahine Range, the rugged nature of the ground to be passed over and the impenetrable character of the bush, prevents their being explored to any distance in this direction. Theoretically, I consider it certain that these calcareous beds crop out all along the Ruahine Range, although there are but few points at which they have really been observed, in the southern part, at least. Limestone is reported as occurring in the gorge of the Makaretu River, near the north end of the Seventy Mile Bush. I saw no specimens, and as at the time the whole country was flooded, I had not the opportunity of seeing the rock in question. From descriptions, I should imagine it could be no other than the calcareous rocks of the Manawatu Gorge.

At the Manawatu Gorge, the section is very incomplete, the lowest layer seen being blue sandy beds resting on the old rock, and having at their upper surface about 18 inches of shell conglomerate, followed by 15 feet or 20 feet of marly clay, with fossils in a very tender state. Overlying these beds is a coarse conglomerate about 30 feet thick, and without fossils; calcareous sands of a thickness of from 20 feet to 25 feet then follow, overlaid by fossiliferous conglomerates, passing into marly clays, and again overlaid by hard calcareous sands, which are followed by sands and sandy clays with irregular beds of hard calcareous

sandstone scattered through them; all of which are succeeded by a very considerable thickness of calcareous sands terminating the section in a bluff, at the junction of the Mangamanaia Creek, coming from the Range above Woodville.

The road, from the bridge to this point, runs east along the banks of the river; but from this point turns to the north, and the section is repeated in part. The calcareous sands in this part being quite loose, may be removed with pick and shovel; conglomerates appear as the lowest beds in this direction being the equivalents of the brown sands in the section along the banks of the river.

The strike of the beds in the lower part of this section is N.E. and S.W., with a dip to the S.E. of 45°. In the higher part of the section it is even more to the east, and the angle of dip quite as high, but the irregular character of the stratification makes these observations less to be trusted than the general outcrop of the beds, which throws them more to the north, along the flanks of the main range; in which direction, according to Mr. McDonald, of the Gorge Hotel, they are to be seen near the old track which crosses the range north of the gorge. As, in following these rocks to the north, I shall have occasion to speak of a higher division of them, overlying the calcareous member, which closes that part of the series of which I have already treated, it may be as well to notice the various localities in which this lower division is exposed, before entering upon a description of the higher members of the series.

From the junction of the Manawatu River with the Mangatinoko, four miles S.E. of Woodville, a low rugged limestone range may be observed striking north, while a considerable extent of level country must intervene between this and the Puketoi Range. This lower range seems to be a continuation of the high terraces composed of calcareous sands and conglomerates, described as beginning ten miles up the Mangatinoko, at the second or middle crossing of that river; and which, though necessarily broken through by the Tiraumea River, continues as a well marked line of elevation, till east of a point ten miles north of Woodville it either joins the Puketoi or is lost in the broken country on the left bank of the river. Limestones certainly cover a great part of the Puketoi Range and its northern continuation to the east of the Seventy Mile Bush, where its direct line of continuation terminates near the railway crossing of the Porangahau Creek; but a few miles to the south, the limestone and lower beds of the same series are divided into two exposures, by the appearance between them of the

older rocks already described as occurring here. The limestones to the west terminate as above described, and merit no particular description; they are underlaid by a considerable thickness of sandy clays, and near their higher beds are interstratified with beds of brown sands. The strike is N.—S., and the dip west, at an angle of 20°. To the east of the old rocks the limestone range is cut by a saddle at the source of the Maharekeke River, from which point it is a continuous range as far as the Tukituki River, cut, however, by two low saddles, through one of which the railway passes from the Ruataniwha Plains into the level country south of Waipukurau; the other, three miles further south, connects in like manner the level country on either side of the range. North of the Tukituki River, the limestone rather flanks this range on its western side than forms it, the greater mass and higher ground being formed of secondary chalk marls, as far as Karori, where they terminate; the limestones again form the range as far as Pakipaki, at the south end of the Ahuriri Plains. A valley, along which runs the Main South Road and railway line, here divides this range from that behind Havelock, west of the Tukituki River. The intervening valley is, however, covered with limestone, and no stratigraphical break takes place; the limestone, rising in a high range, strikes N.E., and after crossing the Tukituki, not far from the crossing of the river leading to Waimarama and the East Coast, strikes from this point to the shore, one and a half miles inside of Cape Kidnappers. Where the railway line cuts this range, blue sandy beds may be seen to underlie the limestone, but generally the nature of the underlying beds cannot be made out; the eastern sides of the range being much covered with *débris*, and the low grounds by extended lake deposits.

South of the Waipawa River, where the junction of this series with the underlying chalk marls can be seen, the limestones lie hard upon the secondary rocks, without the intervention of the lower members, and this is also probably the case as far as the secondary rocks run to the north; the greatest development of the underlying beds taking place along the East Coast, as for instance at Cape Kidnappers, Black Head, and at Cape Turnagain.

I have already mentioned the probability of these limestones, and the underlying beds of the same series, skirting the flanks of the Ruahine Range, from the Manawatu Gorge north, but nothing is known of their existence until, as I have said, report speaks of them as being present in the gorges of the several rivers crossing the Ruataniwha Plains; and,

although I did not see them myself, I should still consider their occurrence along this line as very probable. It was not till within three miles of Kereru Bush that I again observed them striking north, along the flanks of the Wakarere Range, at first as patches of limestone, apparently lying hard upon the old rock. The country here is so broken and rugged that it is a matter of some difficulty to reach the more southern patches of limestone; but at the northern end, whence the limestone strikes in a continuous ridge for some distance north, the ground is open and clear, and several creeks cutting deep into the strata offer, with a little trouble, excellent opportunities of observation. The limestones themselves, the beds underlying, and those overlying, for a considerable distance are much disturbed, and, in one place, quite overturned, so that only after a careful study of the section exposed in the neighbouring creek, are their true relations to be made out. Besides the limestones, the underlying beds (blue clays with concretions) are here exposed, and though of no very great thickness, are full of fossils, especially near their junction with the limestones. Striking north, the limestones are seen to within a short distance of the Ohara River, at the point where it strikes west to pass behind the Wakarere Range. Here the limestone turns also to the west, and after being obscured for some distance, is next seen flanking the west side of the Wakarere Range, striking south with a westerly dip, and re-appearing on the other side of the valley, flanking the Ruahine Range, and there having an easterly dip. North of the Ohara River, between the gorge of the Ngarururoro, it does not appear to be present, nor in the section exposed in the lower part of the gorge of the latter river is the limestone to be seen; but within less than half-a-mile of the north bank it begins as low hills, having about 150 feet of marls between it and the underlying serpentinous rocks; and a mile and a half north of this, they rise into a range 1,200 feet above the level of the river, at the lower end of the gorge. This limestone range strikes away due north, apparently without any break, except the saddle through which the road to the Patea country leads. It slopes to the east, nearly coincident with the dip of the beds, 17° to 20°, and on the western side presents a steep broken scarp; to the west of which the lower beds crop out as a rough country full of slopes and covered with high fern. The beds under the limestone are not here richly fossiliferous, but have the large fine-grained concretions, which characterise them, and which, as a rule, may be said to be absent from beds of similar composition which overlie this limestone.

Returning to the Kereru and the northern slopes of the Wakarere Range, at Mr. Lyon's out-station, and along the rising slopes of the range to the south, patches of limestone occur at intervals to a height of 500 feet above the plain, showing that originally the beds swept over this part of the range and connected with the limestones in the upper part of the Ohara River, between which and the main ridge of limestone, at the eastern foot of the range, a narrow belt of the underlying beds intervenes; over which, in one place, the limestone descending from the higher level sweeps nearly continuously, and then dips at a very high angle (almost vertical) to the east. On crossing the Deep Creek, near Duff's station, three-quarters of a mile further to the south, the limestone is vertical; and less than half a mile further south, on a conical hill rising 360 feet above the flat, it is completely overturned, dipping west at an angle of 45°. A westerly dip occurs on this hill only; elsewhere, the beds are vertical, or have a high dip to the east.

The wide sweep of the limestones round the northern end of the Wakarere Range encloses, between this point and its outcrop, on the east side of the Ohara Valley, a considerable area of the lower beds, with fossils and characteristic concretions; but I did not in this locality make any collections, considering that made at the Kereru Bush sufficient.

Beds of conglomerates are sometimes interbedded with the limestone, as may be seen where it crosses the creek at Duff's.

Higher Beds of the Hawke Bay Series.

From the great distance between the two lines of exposure, and the considerable angle of dip to which the lower beds attain, it will be apparent that even should the dip of the beds lessen rapidly towards the middle of the syncline, a very considerable series of beds either conformable or unconformable must overlie the Tertiary beds already described. The bulk of the evidence collected by me points to the conformity of the overlying beds about to be described, and I shall speak of them as the higher division of the Hawke Bay series. Wishing it to be understood that what might under the old classification be considered as the lower beds, do not in any way belong to this series; I here allude but to that horizon of which the Taipos, on the east coast of Wellington, may be taken as a type.

Beginning at the most southerly point where this higher portion of the series was observed by me; namely, in the high terraces south of the Manawatu, lying between Mangatinoko and the Mokanga Rivers;

the lower beds closed by limestones, striking south from the gorge, and dipping east at a high angle, must necessarily imply that the beds to the east of them overlie; and the westerly dip of the same limestone, ten miles above the junction of the Mangatinoko with the Manawatu, proves that they occupy a syncline in the intervening space.

Three miles south of the Manawatu junction, they form high terraces or table lands; on the west side of the Mangatinoko, half a mile above the crossing, they appear to be blue clays, and to be overlaid by brown sands, which in the road cuttings are full of fossils. Continuously bad weather prevented me making a collection at this point, as I intended to do, which is to be regretted, as I did not find these beds richly fossiliferous till the Ruataniwha Plains were reached.

North of Woodville, these clays are occasionally seen to crop out in the road cuttings, but do not appear to be fossiliferous at this point. In the large clearing, south of Danewirke, on the east side of the Manawatu, isolated hills are seen; on the western side of one of which is a high cliff, the base of which is washed by the river. In this cliff, brown and white sands (pumice sands) may be seen, with beds of clay. I got, however, but a distant view of this place, as the river at the time was impassable.

After passing Danewirke, the country becomes more broken, the many feeders of the Manawatu cutting deep gullies and crossing the line of road. Good sections here begin to be exposed, but, unfortunately, the line of road and the strike of the beds being nearly coincident, no great range of strata is seen; what is seen in one section being repeated in the next. In the best of these sections I observed the following sequence, which I shall describe in ascending order:—

1. Loose sandy beds, with occasional patches of shell gravel, from which but few perfect shells can be obtained.
2. Blue sandy clays without fossils.
3. Conglomerates; the pebbles small and well rounded, wholly derived from old rocks.
4. Brown sands, with thin seams of impure lignite.
5. About four feet of pure white pumice sands, forming a rock of considerable solidity.
6. Conglomerates, same as No. 3.
7. False bedded pumice sands, with pieces of pumice three or four inches in diameter imbedded.
8. Brown sands of considerable thickness.

beyond which the section becomes obscure, and the sequence cannot be observed. The thickness of the beds in the above section may not be more than 250 feet, but a considerable thickness of strata, without doubt, both underlies and overlies the portion of the section observed.

From Norsewood north, the rivers do not cut through the superficial gravels so as to expose these beds, and I did not see any beds overlying the limestones of the lower division of this series, till at the southern end of the Ruataniwha Plains. Flanking the limestone range on the east side, and in one place rising into low hills, but generally seen in the banks of the creeks, are a series of blue clays with abundance of fossils. These distinctly overlie the limestones, but the conglomerates and pumice sands of the Seventy-Mile Bush are wanting at this place. The same beds probably form low hills on the west side of the plains, but I did not visit them. Not till the northern boundary of the plains is reached, are these beds to be seen making junction with the limestones bounding the plains to the east. At this point, however, they again appear, and are exposed in sections along the banks of the Mangaonuku River, where the beds so closely resemble the pumice sands, etc., of the Seventy-Mile Bush, that there can be no possibility of mistaking their identity. The section in ascending order shows the strata thus :—

1. Grey sandy beds, which here overlie the limestone, dipping west.
2. Pumice sands of considerable thickness.
3. Blue sands and conglomerates, which, as in the Seventy Mile Bush, are overlaid by a yet younger superficial conglomerate, or more properly, heavy beds of gravel.

The beds along the junction of the limestones dip at a low angle to the west (10°); but one mile and a half from this, they are thrown up into a sharp anticlinal ridge, the beds attaining almost a vertical position. To the west of this ridge they soon again flatten to a moderate angle, and, after making a wide syncline, begin to rise to the west, where they rest on the limestone flanking the Wakarere Range. In the western part of this section the overlying gravels blending with the conglomerates of the pumice sands, considerably obscure the section. The strike is nearly N.—S.

In following down the Poporangi Stream, which passes through the Kereru Bush, fine sections of the pumice sands and associated conglomerates are exposed in the side creeks coming from the east. A small stream rising in the Wakarere Range here joins the Main Stream

at the south end of the bush. In this creek, a good section showing the relations of the pumice sands and associated beds to the underlying limestones, is to be seen. After passing the lower beds standing at a high angle, these are followed with a gradually lessening angle of dip to the east :—

1. Blue sands and clay beds, dip east 60° (in the higher beds this falls to 30°), where a bed of lignite separates them from
2. Pumice sands and conglomerates, which, with interbedded clays shortly become horizontal, and passing a low anticline which again exposes the lignite bed, dip away to the east, rising into a series of hills about 1200 feet high on the east side of Kereru Bush.

In the creek at the south end of Kereru Bush, near Mr. Duff's home station, and which has already been alluded to in describing the lower members of this series, a fine section is to be seen, although the one further to the south just mentioned shows the relations of the pumice beds better. The following sequence may be observed :—

1. Clay marls (with fossils) vertical : 30 feet.
2. Grey or blue sandstones or sands : 200 feet.
3. Blue clays full of fossils ; often as shell beds : 400 feet.
4. Conglomerates, sands, clays, and pumice sands follow, of great thickness.

The strike of these beds is the same as the underlying limestones, the angle of dip gradually falls to 35° at the junction of the pumice sands, and to yet lower angles further to the east.

These beds are in part overturned at a point half-a-mile to the south, the limestones there quite underlying the lower members ; it was only after considerable trouble that their true relations were made out. From this point north the pumice seems to thin out, and its place is taken by blue clays which, when exposed in the banks of creeks, slips, &c., is of a light color and marly appearance. This marly character of the beds has quite asserted itself three or four miles to the north of Kereru, and the beds from this point north are sands and sandy clays with, in the lower part, alternations of thick beds of fine-grained conglomerates and clays parting them from an upper series of clays and marls, the whole seen to great advantage along the banks of the Ngaruroro River.

The beds can be traced continuously to the Ngaruroro River, by following continuously the two prominent bands of conglomerate

mentioned above, which cross the river a little below the junction of the Otamauri Creek with the Ngaruroro, and from this point may be traced up the river in a clear continuous section, or down the river till overlaid by loose or consolidated shell beds, which close the sequence. In speaking of the limestones and other lower members of this series, I have already mentioned that they are not actually seen in the banks of the river at the lower end of the Ngaruroro Gorge, but that the limestones begin about half-a-mile to the north of the river, having an inconsiderable thickness of the underlying beds between them and the old serpentinous rocks which form the gorge. At first the limestone is much disturbed, and caps a few isolated hills, without appearing to dip under the overlying beds; but, on its becoming a continuous range, striking away to the north, it is so distinctly traceable into the valley of the Otamauri Creek, that it cannot otherwise than be the upper part of the series now being described. The beds in the lower part of the section are sandy, and in places full of fossils. Opposite the junction of the Oharo River there are sometimes loose brown sands full of *Pecten radiatus*; beds of a more marly character follow as far as a little below the junction of the Otamauri Creek, up to which point the dip has been quite uniform—it is here east, at an angle of 17°. At this point the first bed of conglomerate comes in, overlaid by more marls, and then of like character to the first conglomerate, No. 2 comes in, the two, with the intervening clay beds, forming a ridge of hills striking away to the north. At the western end of the Matapiro Plain a third conglomerate comes in, and forms a bold scarp on the east side of the Kikowhero Creek, above the point where it reaches the plain; this latter conglomerate (No. 3) may be seen dipping at a low angle some distance down the creek, which skirts the northern boundary of the plain. The dip of conglomerate No. 3 is not more than 10°, but the coarse character of the material prevents this being determined with certainty. In the banks of the Ngaruroro River the overlying beds, which are tough blue clays weathering white, seem to have a slight westerly dip, but shortly again dip east, and are overlaid by conglomerate No. 4,—a most remarkable deposit, consisting of conglomerates and sands derived from the older rocks; also sparingly, pumice sands and green-sands. The greatest part of this conglomerate is false bedded at high angles, which gives it an unmistakeable appearance of unconformity. It is exposed along the banks of the Kikowhero Creek, for a distance of about one and a half miles, and is there, at its western termination,

seen to thin out and wedge itself into the clays. Further down the creek the conglomerates thin out, being previously overlaid by the blue clays; here all manner of bedding takes place, but in most cases with an easterly dip. The clays underlying have, in some cases, been eroded before the deposition of the gravels, but there are, in the overlying beds, the same fossils as in those underlying, and the presence of these gravels in no way disturbs the general strike and dip, which is here in the beds above the conglomerates, N.—S.; dip, 5° east. The false bedded conglomerates often strike north-east; sandy marls and blue clays, fully 300 feet thick, overlie the conglomerate bed No. 4, and then this sequence is closed by a thick bed of broken shells and calcareous sands, which, from the junction of the Kikowhero Creek with the Ngaruroro, to the eastern boundary of the Ahuriri Plains, lies nearly flat, exposing the blue clay beneath it. I followed these calcareous sands, or shell limestones, north, across the Waitio Creek, to Lake Okawa, where they are found in the low ground surrounding the lake, as well as on the surrounding hills. West of this place they cap a high hill, between Lake Okawa and the Tutaekuri River, behind which, at its western base, I learned conglomerates occur, which would seem to correspond with the false bedded conglomerates (No. 4) just described; or, as all the conglomerates seem to have a tendency in this direction, they may here unite to the exclusion of the clay marls, which, in the Ngaruroro section, separate them into four distinct beds of conglomerates.

Crossing the saddle leading from the Okawa Lake to the Tutaekuri River, the limestones are seen still dipping at low angles to the east, and here the underlying beds are associated with beds of pumice sands. Following down the north bank of the river the beds dip east, till at Puketapu the limestones reach the level of the river, and beyond this, between Puketapu and Taradale, they again rise, with a low dip to the north-west. At Puketapu, three miles from Taradale, pumice sands immediately underlie the shell limestones, and from this to Taradale light grey sandy marls only are seen along the road, the limestones capping the hills to the north. These marls form the west side of the Napier Harbour; Watchman's Island, in the harbour; and the lowest beds exposed in the south-west side of Scinde Island, along the railway line between Napier and the Spit. They dip to the north-east, bringing the limestones to the sea level at the north end of Shakespeare Road, but are found at a higher level in the Bluff, along the sea beach.

As I found the shell limestones, which close the Ngaruroro section, distinctly overlying pumice sands in the Tutaekuri Valley, and also at Scinde Island, while at the northern bouudary of the Ruataniwha Plains they overlie the limestones forming the range west of Kaikoura, I determined to follow the section from the limestones at Pakipaki to the west, until reaching the higher limestones on the Ngaruroro River, and thence south to its termination.

In doing this, I found the limestone near Pakipaki dipping down to the level of the plains, and the hills west of this limestone range composed of clays, with fossils agreeing with the higher part of the Ngaruroro section, which, as a series of isolated hills forming no regular range, strike away south, and to the westward of which, with a bold scarp facing the east, are overlaid by the higher shelly limestones, which, followed south, gradually converge towards the lower limestone, till in very rough and difficult ground (Raukawa Bush)—the two approach so closely that a contact may here take place. While engaged in this work it rained continuously, so taking into consideration the intervention of the clay marls between the limestones at Pakipaki, and those in the higher part of the Ngaruroro section, I decided not to expend more time here, thinking that these sufficiently attested the existence of a higher and lower limestone, backed, as it is, by a mass of evidence scattered through this report.

From the hills behind Havelock, and thence crossing the Tukituki River, and terminating on the southern shores of Hawke's Bay, between the Maraetotara Creek and the limestone bluff, one and a half miles from Cape Kidnappers, are a series of conglomerates, clays, and pumice sands, overlying a thick bed of coarse limestones, which, as I have already pointed out, is connected with (that is, the limestone may be traced continuously) the limestones forming the range at Pakipaki, and the hills west of Te Aute. Ii is therefore evident that these limestones are the same, or belong to the same horizon, as the limestone occurring at the Ngaruroro Gorge, and along the flanks of the Wakarere Range, and, therefore, as they are quite conformable, it is reasonable to suppose that the conglomerates, clays, etc., of the Cape Kidnappers section, are the equivalents of some part of the section between Shrimpton's and the Ngaruroro Gorge, and consequently lower in the series than the calcareous rocks of Scinde Island, and the opposite main land west of Napier Harbor.

On the north side of the Manawatu Gorge, the hills, which rise to a

height of 1050 feet above the level of the river, at the lower end of the gorge, shew in the gorge nothing but old rocks; but a little to the north of this (on One Tree Hill) conglomerates and beds of brown sandstone appear. The strike is here E.—W., with a dip to the north of 15°. A comparatively low saddle cuts the Ruahine Range a little to the north of this, and through this saddle these conglomerates, sandstones, etc., seem to be continuous, between the Seventy-Mile Bush and the low country on and west of the Pohangahina River. Traced to the west these beds pass into alternations of conglomerates, pumice sands, and blue clays; the strike along the Pohangahina River being N.—S., with a dip to the west of 35°. A good section, illustrating this association of conglomerates, pumice sands, and clays, may be seen near the junction of the Pohangahina with the Manawatu River. Fossils are not very plentiful in these beds, but from the more clayey parts of the pumice sands I obtained a few; the forms, however, appear to be mostly recent. A continuation of these beds appears to skirt the range, on the west side, for some distance south of the Manawatu Gorge.

These beds, striking east and west through the low saddle in the range north of the gorge, and thereby most evidently connecting with the conglomerates and pumice sands of the Seventy-Mile Bush, would, if the limestones at the upper end of the Manawatu Gorge flanked the Ruahine Range, without a break in the exposure from this point, undoubtedly be unconformable to the limestones at the gorge; but observations made at the upper end of the gorge, show the limestones there to be striking N.E. and S.W., and dipping to the S.E. Nothing is therefore more probable than that the lower part of the series here forms an anticline, on the north side of which the limestones would again be exposed, and on which the higher beds might lie conformably. Further than the above, no facts have been observed in support of this view in this part of the district, and, as the convergence of the higher limestones of the Scinde Island horizon towards the lower limestone west of Te Aute, if not their absolute contact there, may be taken as an evidence of unconformity between the higher and the lower limestones. I will venture no decision on this subject at present.

Younger Gravels and Superficial Deposits.

Throughout the greater part of the Seventy-Mile Bush, heavy beds of gravel overlie unconformably all rocks of the age of the pumice sands, on the upturned edges of which they are seen to lie. Gravels, presumably the same, overlie the pumice sands, between the northern

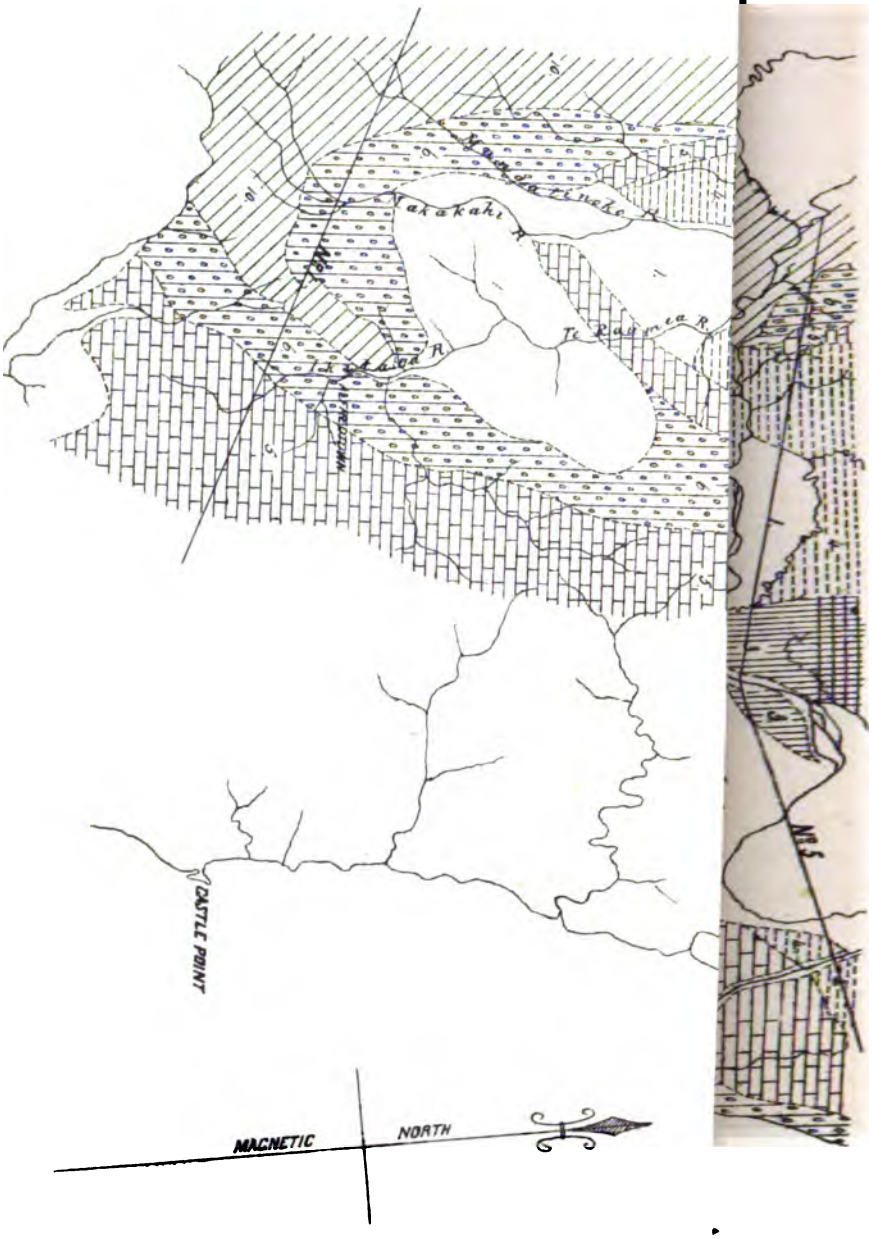
end of the Ruataniwha Plains and the Ngaruroro River, beyond which I did not observe them. These gravels are all confined to the great synclinal trough, lying between the Ruahine Range and the Puketoi and its northern continuation; not having observed anything like them on the east coast of the North Island, south of Napier. The high level gravels, north of Palmerston (where unconformable to the pumice sands), might also be considered to belong to the same period; only in the Seventy-Mile Bush they are not nearly so well rounded as in the neighbourhood of the lower end of the Manawatu Gorge; the only locality in which I have seen these gravels west of the main range. On the south side of the Manawatu River, opposite Woodville, they cap as well-washed gravels, the high terraces between the Mangatinoho and Mokango Rivers. In the Seventy-Mile Bush they are much more angular than in other localities observed, and, in many places, especially in the neighbourhood of Norsewood, remind one of a glacier deposit; here, the finer material, though quite as angular as the coarser, has, as shown in the road cuttings, a stratified appearance, which, with a considerable admixture of clayey matter, gives it the appearance of Till. The Ruataniwha Plains, as river gravels, are evidently younger than these beds; and, at the southern end, as well as north of the Ruataniwha Plains, they cover the higher levels in the western part of the low country, extending as far as the south side of the Ngaruroro Gorge, where, as old river gravels, they form a thick bed on the top of a hill fully 400 feet above the level of the river which it overlooks. In the Seventy-Mile Bush lignite, as thin seams, sometimes is seen lying between these gravels and the pumice sands. At this point the materials are evidently derived from the old rocks lying immediately to the west, and at the Ngaruroro Gorge their river origin is shown in the large and well water-worn boulders which are found on the high levels up to 400 feet above the level of the river. These I have associated with the gravels of the Seventy Mile Bush, rather than with those of the Ruataniwha Plains, because at the time of their deposition neither the Ruataniwha Plains nor the River Plains to the north, at least such as they now are, existed.

The Ruataniwha Plains are due to the numerous rivers which traverse their area continually having shifted their channel; and thus, by the pulling down and removal of the older gravels, have within comparatively recent times, formed a nearly level plain; while the older gravels of the Seventy-Mile Bush form hills and valleys, occupying as

they do a higher level, and having been subjected to a much longer period of denudation.

Ahuriri Plains.—These plains, extending from Napier south to the limestone range at Pakipaki, a distance of 20 miles, with an average width of about 10 miles, present some peculiar features, which may merit a special description.

Since the deposition of the latest of marine beds in the district the sea has encroached on the coast line, and, in process of time, removed simply by the recession of the cliffs, if not the whole, certainly a large portion, of Hawke's Bay, leaving Scinde Island; and, in the Napier Harbour, Watchman Island, the former still preserving the higher beds, showing the level at which the land stood. This is also in part shown by the line of cliff bounding the southern end of the bay, though here, from the circumstance of their being connected with the mainland and the different character of the material forming the beds at the surface, they have suffered a greater amount of denudation. The line of limestone hills bounding the plains on the west, show the former extension of the bay. When the land had been encroached upon to the extent pointed out, the shingle brought down by the Tukituki River began to form a spit extending northwards in the direction of Scinde Island, and eventually a large saltwater lagoon was formed, open at its northern end; and I hope to be able to show that the spit which now divides Napier Harbour from the northern part of Hawke's Bay is younger than that running from Scinde Island south. Immediately the spit as far as Scinde Island had been raised sufficiently to prevent the scouring action of the sea within the area enclosed, the large rivers coming from the west deposited the materials brought down by them in still water, which no longer spread along the beach by a heavy surf, pushed itself out as a fan into the still waters of the lagoon. This effect is most apparent in the part of the plains now crossed by the Ngaruroro River, which was pushed so far as almost to cut off the lower third of the enclosed space from communication with the northern part. The Tutaekuri River acting in like manner also built a fan, which was either directed more to the south or did not reach so far east as that formed by the Ngaruroro River. These fans extended thus far, the real formation of the plains was now begun. The completion was accomplished in great part by the filling up of the southern end with a deposit of pumice, brought down by the Ngaruroro River, which, not having had an opportunity of observing, I but suppose is largely present between the Ngaruroro and


Nakakahi R
Te Rauroa R
CASTLE POINT
MAGNETIC
NORTH

Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S., DIRECTOR.

To illustrate Report by A. McKAY. February 28, 1877.

TION N°4

SECTIONS

MASTERTON TO NAPIER

Reference.

1a. Recent River Gravels, Raised Beaches &c
1c Old High Level Gravels
2a Seinde Island Limestone
2b & c. Gravels, Sands and Clays, Cape Kidnappers &c.
3b. Limestones, Wairarapa, Te Aute &c.
3d Concretionary Sandy Clays
5. Calcareous Sandy beds & Blue Clays in concretions
7. Conglomerates, Sandstones, Shales, & Chalk Marls
8a. Sandstones, Conglomerates & Shales
11. Rimutaka Series. Serpentines Slates &c.

the Tutaekuri Rivers. Thus, at least along the Ngaruroro River, it may be observed that the river running on a higher level than a considerable part of the plains, has on either side of it extensive swamps, beneath which, without doubt, a heavy bed of pumice gravels and sands occur, the edges of which are to be observed all round the margins, save along the spit between Scinde Island and the mouth of the Tukituki, along which line the accumulated waters principally made their escape, till the Ngaruroro, pushing its fan right across the intervening space, at length discharged itself into the sea direct, and thus checking the waters of the Tukituki, the latter river no longer supplied materials for the maintenance of the Spit; but the materials brought down by it were now employed in forming a delta at its mouth, and eventually the formation of another smaller spit between the mouth of the Ngaruroro River and the mainland on the right bank of the Tukituki. On the union of the south spit with Scinde Island being effected, and upon the partial filling up of the enclosed space, the ebb and flow of the tide being now less in volume and consequently having less power to prevent the formation of the northern spit, the current also being thrown off the coast line by Scinde Island, conditions favourable for its formation existed which can hardly have done so before; and thus, while the spit from Scinde Island admitted of the formation of the plains by the rivers, it also in time was the occasion of the northern spit enclosing that portion of the bay which now forms Napier Harbour, and which the same agents operating upon it is slowly but surely filling up.

Description of Map and Section.

In these I have incorporated the results of a former examination made by me between Cape Kidnappers and Castle Point, on the east coast of Wellington, thereby being better able to show the relations of the different strata more particularly, as regards the section from the Taipos to the west side of the Manawatu Gorge; as, except it be from the Pourerere River to Black Head, no other section shows the whole range of the tertiary rocks,—from the lower foraminiferous limestones to the pumice sands and lignites, which underlie the Scinde Island limestone.

Neither map nor sections are to be considered as anything more than an approximation to the truth, as much of the country which they illustrate is of such a character as to render accurate investigation almost an impossibility, until greater facilities of communication are opened up. The following is a table of the different groups of rocks occuring in the

district, numbered and lettered in accordance with the latest classification supplied by the Director of the Geological Survey :—

I.	Recent—Recent river gravels, raised beaches, lake deposits.		
II.	Pleistocene	1. C.	
III. IV.	Pliocene	2. A.—Scinde Island limestone. 2. B. and C.—Gravels, sands, and clays, pumice sands, and lignite.	
V.	Upper Miocene	3. B.—Limestone—Wairarapa, Forty-Mile Bush, Manawatu Gorge, Cape Kidnappers, Kereru.	
VI.	Lower Miocene, and Upper Eocene	4. A. B. C. 5. A. B. C.	Sand and clays, with shell beds; blue clays, with concretions; calcareous sandstones, nummulitic limestone.
VII.	Cretaceo Tertiary	6. C.—Tufaceous greensands, near Waimirima.	
VIII.	Upper Cretaceous and Lower Greensands	6. D. E. F. G.	Chalk marls, green sandy shales, sandstones, and conglomerates, trap rocks.
IX.	Middle Secondary	9. B.	Conglomerates, green and grey sandstones, dark crumbling shales; Wakarere Range, etc.
X.	Rimutaku Series— Palœozoic—	11. B.	Sandstones, slates, red cherty rocks, serpentinous shales.

No. 1.—Section A.A.,

From the Taipos, in the Warehama Valley, to the Tararua Range, shows the old tertiary rocks (5. C.) resting on the lower beds of the cretaceo-tertiary series. This rock is a hard white limestone, almost composed of various forms of foraminiferæ, amongst which *Cristellaria haasti* is by far the most abundant; marly strata intervene between this limestone and the Taipos, and show in the valley of the Tenui River, the absolute correlation of which may be uncertain, but which occupy the position of 5. B. Higher in the section, the Taipos themselves, a series of isolated hills composed of sands and hard sandstones, contain a variety of fossils, which show them to be related to the lower beds of 4, and they are here placed as 4. C., which is considered to be lower Miocene, although I am not aware of the occurrence of an unconformity between these and the underlying Eocene rocks. Overlying the beds forming the Taipos, in the Maungapakeha Valley, are a series of fossiliferous sands, full of shells, which seem to be the higher

beds of No. 4.—4. B., and may be considered to represent the gravels which close the Miocene rocks in the South Island. Sands, highly fossiliferous, overlie these in the country drained by the Tauheru River, these (4. A.) are followed conformably by 3. B. and C., chiefly consisting of calcareous sands, though, in places, interbedded with bands of conglomerate, as at the Manawatu Gorge.

This limestone is followed, in the northern part of the Forty-Mile Bush, by grey sands, underlaid by clays, which are either 3. A. or 2. C.; but, in colouring the map, I have not been able to distinguish these beds so as to separate them. This same difficulty applies to the section crossing the south-eastern corner of the Ruataniwha Plains, where the beds following 3. B. are, in all probability, 3. A. On the west side of the Ruahine Range 2. B. and C. are largely developed in the country between the Manawatu Gorge and the Rangitiki River, but almost completely obscured by 1. C. Old rocks appear on this line of section, on the watershed between the Ruamahunga and its tributary rivers, and the waters flowing north to join the Manawatu River, and throughout the whole length of the Manawatu Gorge. This section is the most important which may be seen in the whole district, as at one or other point all the rocks occurring in the district, with two exceptions (9. B. 2 A.) are represented.

No. 2.—Section through the Manawatu Gorge.

The old rocks here forming the northern part of the Tararua Mountains, and the Ruahine Range to the north of the Manawatu Gorge, 11 B., may be divided into (1) sandstones and slates, overlaid by; (2) serpentinous rocks, black or green, with red quartzites and iron ores. To the west the serpentinous rocks are overlaid by 2 B. and C., while to the east, at the upper end of the gorge, the underlying sandstones and slates are overlaid by 4 A., followed by 3 B., calcareous sands alternating with conglomerates. The alluvial low-lying grounds on either bank of the river prevent this highly interesting section from being followed into the higher beds.

No. 3.—Section from the Ruahine Range West of Norsewood to Paonui Point.

This section in its western part could not be reached, but I have no doubt that it will be found to be very much as represented, perhaps with the addition of 3 B., which is not shown, no limestone appearing in the *debris* of the creeks or older gravels.

The old rocks (11B. and 9 B.) form the Ruahine and the lower range flanking it on the east, while 2 B. and C. are largely developed throughout the greater part of the Seventy-Mile Bush, but in great part obscured by 1 C., as coarse subangular gravels well seen in the neighbourhood of Norsewood. In the S.E. corner of the Ruataniwha Plains 2 C. lies, to all appearance conformably on 3 B., which is underlaid by 4 A., resting on old sandstones 9 B., east of which the low grounds are covered by recent gravels, but in the low banks of the Maharekeke River, and forming a series of low hills in front of the limestone range, bounding the plains to the east, beds probably the equivalents of 3 A., are found conformably overlying the limestones 3 B., which latter are probably underlaid by 4 A., but on account of the low grounds being covered by the deposits of a former extension of Lake Hatuma these cannot be seen, at least without further research than I devoted to this part of the district.

Secondary rocks form Golan's Range east of the Tangituparu Stream, which extend to the vicinity of the Tarawera Bush, where foraminiferous clay marls (5 C.) again make their appearance, lying unconformably on the secondary rocks. In Castle Range secondary rocks again make their appearance, beyond which to the east the lower tertiary rocks (5 C.) continue with slight exception to the sea coast where they form Paonui Point.

No. 4.—Section from the Junction of the Tukituki and Waipawa Rivers to the Ruahine Range, behind Kereru.

The lowest rocks in this section seen in the Ruahine Range are red slates and serpentinous rocks, the same as at the Manawatu Gorge, and these in the valley of the upper part of the Ohara River are overlaid by limestones (3 B.), probably at places underlaid by 4 A., though in many places the limestone is found resting on the old rocks without the intervention of the underlying beds 4 A.

These limestones form a syncline between the Wakarere and the Ruahine Ranges, and occur as patches on the higher ridges of the first-mentioned range in the line of section. The limestones 3 B. and the underlying beds 4 A. flank nearly the whole length of the Wakarere Range on its eastern side, and are followed apparently quite conformably by 2 C., which with the limestones and underlying beds, are often in a vertical position, the latter in one case being quite overturned.

East of Kereru the beds 2 C. dip away to the east at low angles, and are overlaid by heavy gravels belonging to 1 C., which form the hills between the N.W. part of the Ruataniwha Plains and Kereru, but are everywhere seen to be underlaid by 2 C., which is again seen to rest on the limestones forming the Te Aute Hills, west of Kaikoura, and forming the eastern boundary of the plains. These limestones 3 B. are here composed almost entirely of shell-sand, and, without the intervention of any of the lower beds, rest on the light-coloured chalky beds forming the higher beds of the secondary rocks in this district, which, as rocks of the same character, with several variations in dip, are continuous to the junction of the Tukituki and Waipawa Rivers, beyond which the section is but a repetition of No. 3.

No 5.—SECTION FROM THE NORTHERN CONTINUATION OF THE RUAHINE RANGE TO CAPE KIDNAPPERS.

This section, in its western part, shews the beds 4. A. conformably underlying the limestones 3. B., and these, in turn, apparently quite conformably overlaid by 2. C., which latter, in this part of the district, cover a great extent of country, and, after several alterations of gravels, sands, and clays, more or less calcareous, are overlaid near the junction of the Kikowhero Creek with the Ngaruroro River, by the Scinde Island limestone, 2. A., often consisting of consolidated beds of shells. These Scinde Island limestones are the highest beds in the district between the Tutaekuri and Ngaruroro Rivers, excepting the Ahuriri Plains; as, on continuing the section across the plains to the sea cliff, beginning at the mouth of the Maraetotara Creek, and thence showing a clear section to Cape Kidnappers, we find the gravels, sands, and clays (2. A.) overlying limestones, which can be traced continuously from this point, first to the Te Aute Hills, and thence along the eastern borders of the plains to the Puketoi Range, which connects with the limestones of the Forty-Mile Bush and the Wairarapa Valley. In the Cape Kidnappers part of the section, these limestones are underlaid by grey sands, which are probably 4. A., and further to the south of the Cape 4. B. may make its appearance.

A number of sections supplement these, among which that showing the somewhat obscure relations of the cretaceo-tertiary rocks, seen on the coast north of Waimirima, is the only one deserving of particular notice, a description of which is given in my report on the country between Cape Kidnappers and Cape Turnagain, in which I consider these to be quite unconformable to the underlying Inoceramus beds.

This statement will require some modification as in the former report, just mentioned. I grouped these rocks with the nummulitic limestones of Paonui Point and Pourerere River, which are distinctly unconformable to the Inoceramus beds, and which, in this report, are placed as lower tertiary; an arrangement which will not apply to the tufaceous green sands of the coast north of Waimirima; and although these I considered to be unconformable to the Inoceramus rocks, I may have been mistaken, as the shore line where they are best seen is much disturbed by faults and slips, and as an examination of the fossils show some connection with those from the Cobden limestone on the west coast of the South Island, I prefer for the present placing them in a distinct group by themselves. Other small sections illustrating details at various points will, from their titles be easily referred to the descriptions of them given in the body of this report where they are described.

REPORT ON THE GEOLOGY OF THE WANGAREI DISTRICT.

BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT GEOLOGIST.

April, 1877.

I have the honor to inform you that, in accordance with instructions, having completed my work in the Waikato district, where I had been for a few days inspecting what had been done by Mr. Denniston, I travelled by steamer from Auckland to Wangarei, where I arrived on the morning of the 7th March. On that day, as well as on the 8th and 9th, the continuous rain prevented any work being done; but, on Saturday, the 10th, I went, accompanied by Mr. Denniston, to visit the Whau Whau Coal Mine, going through the workings and observing the beds which overlie the coal in that locality; also noting the beds to be seen going to and from the mine, and more especially the limestone which is at present being quarried on the banks of the creek which empties itself into the Wangarei Harbour, to the east of the wharf, and which rise at the back of the Whau Whau Coal Mine. I then went on to Kamo (Meldrum's Mine), but did not go through the workings there, as operations were suspended at the time of my visit; I, however traced the boundaries of the slates, etc., in the district.

After this I was again detained by the exceptionally bad weather until Tuesday, March 13th, when I visited the Whareora coal outcrop, and thence round by Mount Tiger to the Awaroa Creek, getting back to Wangarei along the southern side of the harbour.

On Wednesday, March 14th, in the morning I examined the limestone beds near Wangarei, with a view of collecting from them and also tracing their extent; and in the afternoon I examined the tufaceous beds of Mount Parahaki, opposite the Wangarei Township.

On Thursday, March 15th, having borrowed a boat, I went down the harbour to the Awaroa Creek, with the intention of going over the ground there with Mr. Dent and seeing what had been done with the borebholes, etc., which had been put down by Mr. Bedlington and himself to prove the country for coal, but, finding that he was not at home, we went farther down the harbour and examined the beds at various points.

On Friday, March 16th, I went to Limestone Island, the examination

of the beds of which took me the whole day; and on the 17th I went to the Wangarei Falls, where columnar basalt occurs, and thence across country to Kaurehorehore, examining the limestone and other beds which appear above the coal at the Kamo Mine, also the trachytic beds of the Blue Mountain. I procured to-day some specimens of fossil fish which had been found in the Wangarei limestone.

On Monday, March 19th, I went down the harbour to the Awaroa Creek, where, in company with Mr. Dent, I examined the district which he had been prospecting for coal, and also the limestone in which the Whareora caves have been formed.

On Tuesday, March 20th, having obtained horses, I rode with Mr. Denniston towards Mangapai, carefully observing the beds throughout the distance travelled, and noting the occurrence of marly beds associated with the limestones on the hills.

On Wednesday, March 21st, I rode over to Hikurangi to inspect the coal measures thereabouts, and on Thurday, March 22nd, having packed and despached my collections, I went to the Heads, leaving Mr. Denniston to prosecute his more careful work as regards tracing the coal boundaries, the results of which work will be found in his report on the district.

On Friday, May 23rd, I went by boat to Bream Head, and landed at most points between there and the bay where I was staying, noting the volcanic beds, and also the limestone which Mr. McLeod has lately been shipping to Auckland.

On Saturday, May 24th, rode over to Pataua, passing a considerable development of trachytes, and then coming on the slates which appear near the mouth of the Pataua River. I also examined the sand dunes along the coast, whence Mr. Thorne has described some moa bones.—Trans. N.Z. Inst., 1876.

On March 25th I further examined the beds of the Bream head range forming Bare Hill, and on the 26th went by boat to Parua Bay, calling at various points, and examining the Manganese slates and the brown and green sandstones of the coal formation there, also certain calcareous beds.

On Tuesday, March 27th, I ascended Manaia in the morning, partially to examine the rocks there *(trachyte breccias)*, and partly to get a good view of the country, so as to be able from general observation to form an opinion as to how nearly my work will correspond with the general character of the country. In the afternoon I collected from the

Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S., DIRECTOR.

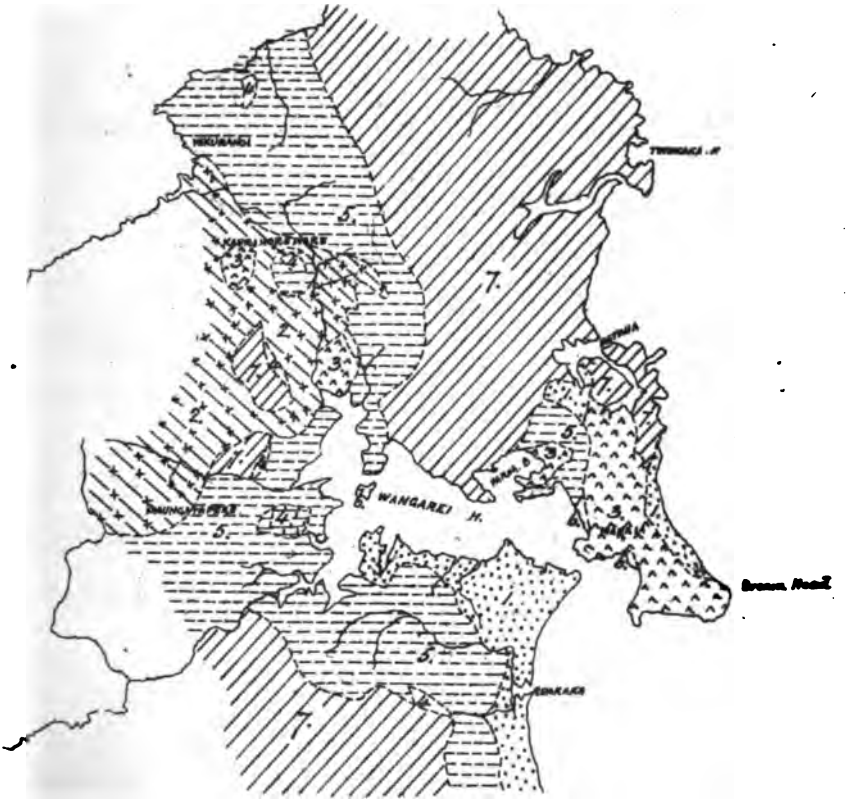
To illustrate Report by S. Herbert Cox, F.G.S., Assistant Geologist. April, 1877.

PLAN

OF THE

WANGAREI DISTRICT

- Harbour Deposits and Blown Sands
- Basalts and Basaltic Tufas
- Trachytes and Trachytic Tufas
- Upper Limestone
- Brown and Green-sandstone with Coal
- Lower Limestone, replacing Coal
- Manganese Slates

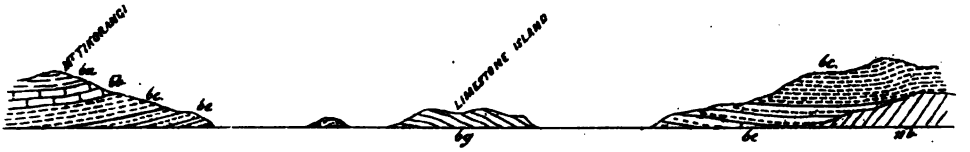


Geological Survey of New Zealand.

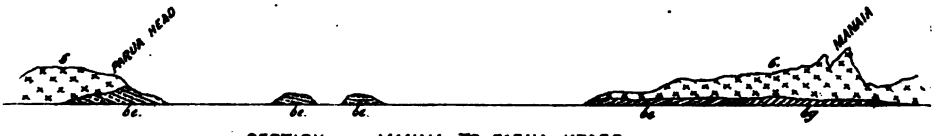
JAMES HECTOR, M.D., F.R.S., DIRECTOR.

To illustrate Report by S. Herbert Cox, F.G.S., Assistant Geologist. April, 1877.

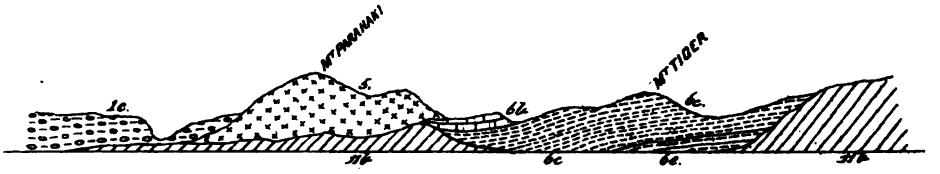
SECTIONS - WANGAREI



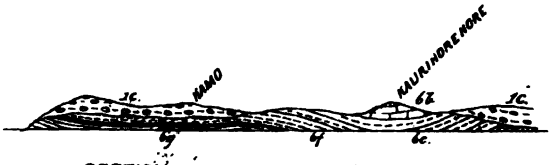
SECTION - MT TIKORANGI AND LIMESTONE ISLAND



SECTION - MANAIA TO PARUA HEADS



SECTION - MT PARAHAKI TO MT TIGER



SECTION - KAMO COLLIERY

HEAD OF PARUA BAY

SECTION - WHAU WHAU COLLIERY

REFERENCE

- 1c. BASALTIC LAVAS AND TUFAS
- 6c. TRACHYTIC AGGLOMERATES AND TUFAS
- 6a. GREY MARLS
- 6b. UPPER LIMESTONE
- 6c. BROWN SANDSTONE
- 6d. CHALK MARLS
- 4a. GREEN SANDSTONE
- 4f. ISLAND SANDSTONE
- 4g. COAL AND LOWER LIMESTONE
- 3R. RIMUTAKA SERIES

fossiliferous beds at the head of Parua Bay, and on Wednesday, March 28th, returned to Wangarei, whence I took the steamer to Auckland, arriving on the 30th March.

REPORT.

I find throughout this district that the mapping* by Dr. Hector has been most accurate, so that this report will be more specially devoted to the correlation of the beds which occur in this district with those of other localities, and under the names which have been adopted generally for the colony by Dr. Hector.

The following is a list of the beds which here occur, given as they are seen at Wangarei, and compared with beds which are found in other parts of the colony :—

Recent and pleistocene.		Harbour deposits and sand dunes, basaltic lavas and tufas.
Eocene (?)	Trachyte agglomerates, Hick's Bay.	Trachytes and trachytic agglomerates and tufas.
Cretaceo-tertiary.	Grey marls and Amuri limestone, leda marls, Island sandstone.	Upper limestone, brown sandstone, green sandstone (fucoidal).
Lower greensand.	Coal.	Coal and lower limestone, with brown sandstone below the latter; also, volcanic breccia associated with the beds.
Carboniferous (?)	Rimutaka beds.	Manganese and clay slates.

The highest beds in the district are the harbour deposits and sand dunes, which latter require special mention, as being a point from which moa bones have been collected north of Auckland. They were first observed by Mr. G. Thorne, at Pataua, in the sand dunes which occur from there north to the Hora Hora River, and a very interesting description of these remains, their mode of occurrence, &c., is to be found in Mr. Thorne's paper on the same, published in the Transactions of the New Zealand Institute, Vol. VIII., page 83.

* Geological Map of Northern District of Province of Anckland (Sept., 1866), published by the Provincial Government, Auckland.

Belonging to these sand dunes there would seem to be a hard consolidated bed or beds of sand, in which also moa remains have been found, and these appear to be the equivalents of the consolidated sands which occur on the south side of the Wangarei Harbour, between the Mangapai arm and and the Heads. I was unable to find any fossils in these beds at the last-named locality, and, although I have no doubt that they are of quite recent origin, I can offer no proof in support of this.

At Pataua and in that locality I devoted but little time to the examination of these beds, and made no collections, the few specimens of moa bones which I observed being of so fragile a character as to preclude the possibility of preserving them at all. I may mention under this head that human remains are found in various small caves in the Whareora limestone, evidently burying places of the Maoris.

Basaltic Lavas and Tufas.—These are the next beds which require attention. They form low-lying plateau country where they occur, the cones from which they have been ejected being in many cases very apparent. Of these cones perhaps Maungatapere, Mauno, and one at the back of the Whau Whau Coal Mine are the most marked in the district, a lake existing in the crater at the summit of the one near the Whau Whau Mine.

With regard to the matter which has been ejected from these now extinct volcanoes, we find that a considerable area is covered by basaltic beds stretching from Whau Whau by way of the Wangarei falls to Wharcora, and also to the Wangarei township, lapping round the flanks of a slate range near there. It also divides at Mount Parahaki, which mountain rises from the edge of the Wangarei Harbour, being composed principally of trachytic and pumiceous tufas, which will be described in the course of this report.

It also flanks the trachytic ranges about Kaurehorehore, and extends from there towards Hikurangi, and is seen to the S.W. of the Wangarei township as a tongue coming from Maungatapu down the valley in which the track to Wairua has been made.

These beds consist of solid flows of basalt, which at places, as for instance at the Wangarei falls, on the property of Sir R. Douglas, exhibit the columnar structure common to basalt in a most marked and interesting manner. At other places, as at the back of Mr. Bedlington's house, this columnar structure is entirely wanting, and the basalt occurs as regular lava flows.

Certain tufaceous beds also occur associated with the solid basalts, and at places there are decomposing rocks which bear a marked resemblance to trachytes, but undoubtedly belong to this series.

These recent volcanic beds greatly obscure the coal measures and higher beds in that series to the limestones, overlying them and rendering the tracing and determination of the absolute extent of the coal-bearing areas a matter of some difficulty, and one which at the best is somewhat hypothetical.

Trachytic Series.—These beds would seem next to merit our attention, as they certainly overlie the coal measures and calcareous greensand beds which form the higher part of the series. An unconformity exists at the Wangarei Heads, and from there towards Pataua, the calcareous and greensand beds being well seen at the base of Manaia, standing at moderately high angles, while the trachyte breccias rest indiscriminately upon the upturned edges of these various beds.

They differ greatly in character at different points, and may possibly, indeed I regard this as probable, be of different ages at different points, as their great extension points of a period of long-continued activity. We have no data in this district, so far as I was able to ascertain, for fixing their age; but very similar trachyte breccias at Hick's Bay are distinctly overlaid by an oyster bed of the Tawhiti series, which is probably of Miocene age, so that this period of eruption could not have commenced later than upper Eocene times, and very possibly at an earlier date.

At Kaurehorehore these trachytes are solid compact trachyte rocks, the Blue Mountain appearing to be an old trachyte cone, but in the vicinity of this mountain we do not get any extent of the trachytic rocks, as immediately at the base of the mountain the basaltic beds before mentioned are seen.

Eastward of this there is a great extension of trachytic beds, but I did not examine them there.

At Mount Parahaki, immediately opposite the Wangarei township, certain tufaceous beds are seen, white in colour and containing small crystals. Associated with these beds are many included fragments of chert, varying in colour from black to a ferruginous brown. They seem to be pumiceous in character, and from hand specimens could not be distinguished from those beds in the Waikato basin, which occur, associated with lignite, etc., capping the hills to the back of Mercer,

between that point and the Miranda Redoubt, and also occurring away to the eastward of Ralph's Mine.

I am obliged to consider these as belonging to the trachytic series, but admit that their isolated position and their dissimilarity to the other trachytic beds of the district would seem, more or less, to point to the probability of their being of different origin. They rest upon slates, which form the framework on which all younger beds appear to have been deposited in this district and which yet remain to be described.

At the Wangarei Heads, and also between there and Pataua, the trachytic beds are well seen both as solid trachyte flows, and also developed to a far greater extent as breccias, which rise to the very summit of Manaia, where they have weathered to most fantastic shapes.

Cretaceo-tertiary Rocks.—We next come to a consideration of the cretaceo-tertiary rocks, which are the series of beds overlying the coal. They consist, as may be seen by the general list of formations appended, of

Cretaceo-tertiary { Upper limestone,
Brown sandstone,
Green sandstone,

below which in certain areas coal appears, whilst at other points a second belt of limestone is seen which seems to replace the coal.

These beds differ so materially in mineral character from those of the same age which occur further south, that it becomes almost impossible to refer them separately to the various minor divisions which have there been made, and I accordingly only give them their general boundaries.

The above measures, then, may be taken to be the horizontal equivalents of the flaggy limestone of the Waikato basin, the underlying sandstone meeting their equivalents in the *Leda* marls, which term will be understood to comprise, in addition to the clay marls of the Wangape Lake, the brown sands, etc., which immediately overlie them, and which are well seen at Mercer.

The green sandstones which form the lowest part of these beds occur as the roof of the coal in the Whau Whau Colliery (Walton's Mine), and *Ostrea carbonacea** occurs in large numbers in them at that point. This belt of sandstone is undoubtedly the equivalaent of the "Island sandstone" which overlies the brown coal of the west coast of the South

* Colonial Museum Catalogue MSS.

Island, and altogether the beds of the coal measures at Wangarei and the northern part of the North Island generally, would seem to have a closer resemblance to those which overlie the coal at and near Greymouth, than to those which occupy a similar position in the Waikato basin.

At Walton's Mine, as before mentioned, the bed which overlies the coal, forming its roof, is a green sandstone with *Ostrea carbonacea* and other fossils. This bed, the thickness of which in this locality I cannot estimate with any degree of reliability, is overlaid by a banded limestone, in which fossils are by no means plentiful—corals, echinoderms and one or two specimens of a fossilized fish being about all that are known in them. These beds of limestone are exposed in the banks of the creek which comes down from the Whau Whau Colliery, at a point distant from Wangarei about one-and-a-half miles, and lime-kilns have been erected by the side of the harbour whence the lime is shipped direct after being burnt.

This limestone is only being quarried at present from boulders in the bed of the above-mentioned creek, and there seemed to be some doubt amongst the proprietors of the quarry whether or no they would be able to obtain it in the solid. I may state that it may be seen *in situ* on the south side of the creek, but is much obscured by and buried in the basaltic beds which cover so large an area of country in this district.

Similar beds occur above the coal of the Kamo Mine, the limestone, however, only remaining as a small patch near Kaurehorehore, where it has weathered into the most fantastic shapes. Here also a lime-kiln has been erected, but what lime is burnt at this point has to be carted to Wangarei, a distance of not less than five miles, before it can be shipped.

Further inland towards Hikurangi these beds may again be seen, another outlying patch of the limestone capping them in this locality being seen on the side of the old track to Kawa Kawa.

At Wharcora the same beds occur above the seam of coal which has been discovered in that district. They may be traced continuously from that point to the Wangarei Harbour at the mouth of the Awaroa Creek, forming Mount Tiger, at the summit of which they may be seen lying at comparatively low angles.

In the gullies round about Mount Tiger and to the south of that hill these beds may be seen resting unconformably upon the slates, no coal occurring at their base; and in the lower ground, where boreholes

have been put down with the view of proving the country for coal, a lower limestone has been cut, which would seem to replace the coal there, a continuance of marine conditions having obtained while the coal was being formed in the back country.

Overlying the brown and green sandstones to the eastward of Mr. Dent's house the limestones before described are again seen, and they occur here over a somewhat larger area than is the case with most of these outliers. They extend from the point where first seen on the slopes of Mount Parahaki to the Whareora caves, overlooking the Whareora Valley, where coal occurs. These caves are, I understand, very fine, but at the time that I was up there I was unable to go through them, as, owing to the late heavy rains, they were quite flooded out. The dip of the limestones here is W.S.W., at an angle of 25°.

I am indebted to Mr. Bedlington, under whose superintendence the boreholes were put down, for the following sections of the strata gone through; and I shall have occasion further on in this report to refer to the limestones which were struck in the No. 3 boreholes:—

No. 1 Borehole.

	ft.	in.	ft.	in.
Strong yellow clay	3	0		
Strong brown sandstone with minute shells	49	0½	52	0½

No. 2 Borehole.

	ft.	in.	ft.	in.
Alluvial soil	4	6		
Brown sandstone with small shells	141	9		
Black metal band		2		
Hard brown sandstone	46	11		
Hard limestone band		4		
Soft blue clay		2		
Brown sandstone with quartz crystals	37	11	231	9

No. 3 Borehole.

	ft.	in.
Soil and clay	4	10
Green sandstone	33	2
Hard band		4

	ft.	in.	ft.	in.
Green sandstone	3	10		
Hard ironstone band with partings	6	6		
Hard ironstone conglomerate		11		
Hard limestone conglomerate	14	0		
Soft white limestone with hard bands	16	0		
Hard blue limestone	5	1	84	8

No. 4 Borehole.

	ft.	in.	ft.	in.
Soil and clay	7	6		
Brown sandstone (altering in shades from light to dark)	100	5	107	11

To the south of the Wangarei township these beds also occur, and they may be well seen about the Okāika River, after rising from which the limestones occur on the track between Wangarei and Mangapai, and in this locality only, as far as I have been able to make out, do higher beds occur, the grey marls appearing near the summit of the hill and occupying a small surface area only. The limestones are dipping at this point to the S.W., at an angle of 8°.

At the Wangarei Heads a further development of this series is seen, but they cover a comparatively small surface area here. At the base of Manaia and close to the edge of the harbour they are exposed for a distance of about a mile, the dip of the green sandstones being N.E., at an angle of 5°. The lower limestone is also seen here at the very foot of Manaia dipping below the green sandstones, and it appears again at the very head of Parua Bay, where it is overlaid by calcareous sandstone and black marls, the latter being the only beds which could be referred to the *Leda* marls in the district. The green sandstones are somewhat extensively developed at Parua Bay east head, and from that point stretch along the coast towards Manaia, as shown on the map. They consist at this point of brown and green sandstones, dipping south at an angle of 10°, and they contain a fair number of fossils in this locality, but such as there are, are very difficult of extraction.

I omitted to mention above that certain volcanic breccia beds appear to be interstratified with the above beds at the Wangarei Heads; but it

is possible that I am mistaken in this, as the bed in question is precisely similar in character to those which occur in Manaia and at other points above the Heads.

Lower Limestone.—I have at different times, while writing this report, had occasion to mention the occurrence of a lower limestone at certain places in the area under consideration. This limestone is best seen in Limestone Island, the greater part of which is composed of it.

At the northern end of the Island the beds, which are here dipping to the N.E. at somewhat various angles, averaging about 30°, consist of marly limestones, much laminated in character; and, as we pass to the southward, we find a bed of greensand interstratified with them, while on the extreme southern end of the Island flaggy limestones occur, with a dip slightly less than that given above, but representing the lowest member of the calcareous beds, which, as a body, dip below the sandstone, &c., on the mainland to the north of the harbour.

Certain brown sandstones would also appear to underlie these beds on the small island between Limestone Island and the Mangapai Channel, but I was unable to land here and examine these beds, and accordingly can only report their occurrence.

This limestone is evidently the same as that which has been struck in the Awaroa, No. 3 borehole, and it may also be seen at the Wangarei Heads, at the foot of Manaia, as before mentioned, and again in the bay between Manaia and Bream Head.

In the first of these localities it would seem to be of a superior quality, and is being burnt on the spot. In the other it is no better than that found on Limestone Island, and a small quantity of it has been shipped (unburnt) to Auckland, but whether it is to be further quarried or not I have not heard.

The limestone which occurs at the foot of Manaia, inside the Wangarei Harbour, is most unmistakeably dipping below the green sands, &c., which overlie the coals elsewhere, and it is on these grounds, added to the fact that limestone was struck in the No. 3 borehole, on Mr. Dent's property, that I admit this second limestone, and classify that occurring on Limestone Island as the same, since the beds there, although appearing to underlie the green sands, yet scarcely give the unmistakeable evidence which is gained at these other points; neither do the limestones which occur between Manaia and Bream Head, although I feel that I am justified in classifying all these as the same,

from their mineral character, fossils being literally absent throughout, as far as I could ascertain.

The Coal Measures.—The term of coal measures, as here applied, simply means the coal and any beds which underlie it as the roof of the coal, is the lower part of the green sand described above, containing *Ostrea carbonacea* and other fossils characteristic of the "Island sandstone" of the West Coast. Mr. Denniston has reported fully on the coals of this district, and his report appears in this year's publications, so that practically but little remains to be said concerning them. I may, however, mention a few points which appear to me to be specially striking and of interest from a geological point of view.

In the first place, several points have been selected for the opening of collieries and trial drives; and specimens have been forwarded from each of these, the analyses of which are appended to Mr. Denniston's report. From these it will be seen that the quality of the coal varies considerably, but not so much in the different localities as from the different characters of the specimens from the same collieries and outcrops of coal.

The coal from Hikurangi would appear to be the best general coal of the district, and I am informed by Mr. McInnis, the blacksmith at Wangarei, that he used that coal for some time and found it to answer his purpose well. Indeed, he said that he had welded steel with it. He also tells me that for his work it is the best in the district.

Certain samples of coal from Whareora had returned very good results from analysis, but it appears that this is only (as at Kamo and Walton's Mine) the analysis of a picked specimen, which, in the case of Kamo and Walton's, may easily be obtained from the upper foot or so of the coal, where it appears to be of a different quality to the general seam.

For further details about the coal I would refer the reader to Mr. Denniston's report, with which will be found plans of all the workings and all the information which could be gathered relating to the extent of the field, value of the coal, &c.

Rimutaka Series.—It now only remains for me to describe these beds. They are best seen in the district, in Parua Bay, forming the west side of the bay and extending from there up the harbour until nearly reaching the Awaroa River, as may be seen by the map which accompanies this report. They are striking N.—S. at this point, and may be traced through the country to the north, coming down to the coast line at Pataua, and forming all the bluffs along the coast north

of that point as far as I went. They form the principal feature in the country from the coast, west to Hikurangi, where the coal measures come in, capping them on the heights and also descending into the valley at the base of Hikurangi. They occur at the base of Mount Parahaki, near the Wangarei township, and again are seen as ridges at the Whau Whau Coal Mine, where a drive has been put through them to strike the coal at a point which would enable the mine to be worked level free, and also close to the Wangarei township and extending towards Okaika. They again make their appearance south near Mangapai, where they again swell out and cover a considerable extent of country.

They consist of reddish-coloured slates and sandstones, with, at places, heavy beds of decomposed clay slates; Manganese is also found associated with these rocks, deposits of this mineral being at present worked at the Bay of Islands.

Mr. Cafler also showed me specimens of gold in quartz which he had obtained from this locality in the beds of the creeks; but no auriferous lode is at present known, nor did a somewhat protracted search serve to find more than the few specimens now in the possession of Mr. Cafler from the creek beds.

REPORT ON COUNTRY BETWEEN OPOTIKI AND EAST CAPE.

BY S. HERBERT COX, F.C.S., F.G.S.

WELLINGTON, May, 1877.

I HAVE the honor to report that, in accordance with instructions, I left Wangarei on Thursday, the 29th March, having completed my work in that district, and arrived in Auckland on the following morning. On Saturday evening I took the steamer for Tauranga, where I arrived on Sunday, April 1st, and at Opotiki on Wednesday, April 4th. Finding on my arrival at Opotiki that the steamer was going on to Te Kaka, I decided to travel with her as far as this point, so as to avoid going twice over the country between there and Opotiki, and, accordingly, my work did not commence until April 5th, when, having arrived at Te Kaha, I started with the intention of camping at Te Kereu Creek, but did not get so far that night. On the 6th I got to a point about half way between Te Kereu Creek and Raukokore, where I camped; and on April 7th I arrived at Raukokore about midday, and remained there until the next day, wishing to examine the rocks of the district, as at this point a change takes place in their character. On Sunday, April 8th, I left Raukokore, still keeping along the beach, but camped before reaching Whangaparau, having been detained by work at different points. On April 9th I reached the Whangaparau River, and thence took the inland track for Wharekaika, until reaching the point whence the branch track crosses the Coast Range to Okarae. Here I pitched my tent, and on the following morning crossed the Coast Range to Okarae, and from there followed the coast line to Wharekaika, not arriving there that evening, owing to the roughness of the road. On April 11th I arrived at Wharekaika about midday, and having made the connection, between this point and Kawa Kawa, with Dr. Hector's work, which he undertook from the Poverty Bay end, I left again on my return journey the next morning, Thursday, April 12th, taking the Waikohu River as my route. I arrived at my camp in the evening, and the next day reached Mr. C. Brown's station, on the Whangaparau River, and on Saturday, April 14th, I again arrived at Raukokore. From here, I reached a point about six miles

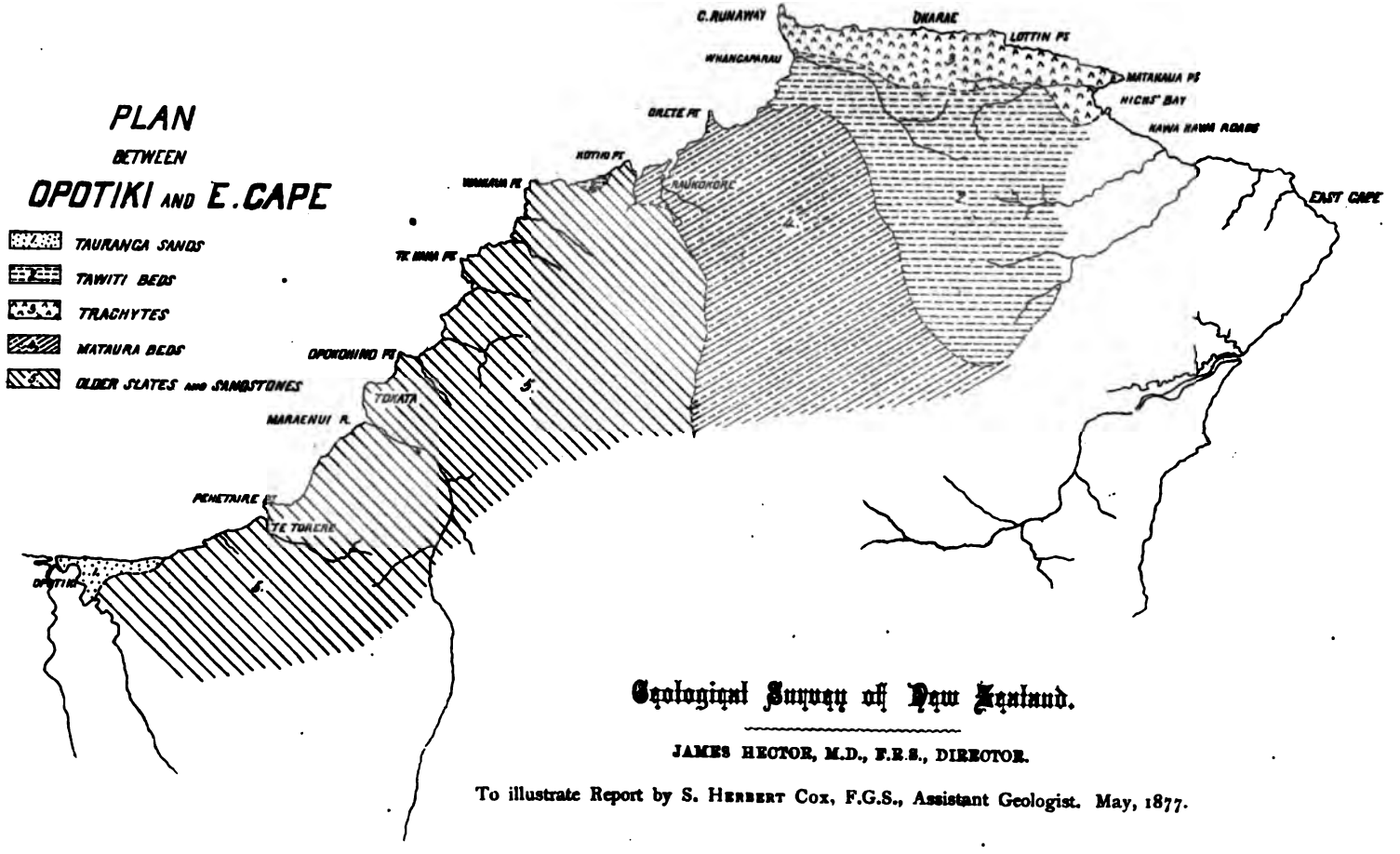
from Te Kaha, and on Monday, April 16th, arrived at W. Black's store, making Torere the next night, and Opotiki on the evening of the 18th, from which place I returned to Wellington *viâ* Auckland, arriving there on Wednesday, April 25th.

The geology of this district, looked at from a general point of view, appears to be moderately simple, but the character of the country is such as to utterly prohibit any attempt at inland work for more than a very short distance from the coast, unless undertaken with a regularly organised party, and with unlimited time. In addition to the roughness of the country, it may be said that nothing at all is known of it a few miles off the beach, as even the Maoris themselves never go inland, and no survey has been made between Opotiki and the East Cape, except that undertaken by the Admiralty for the coast-line, and shewn on the charts. This, however, is of little consequence in the present report, as my instructions were simply to follow the coast-line, and I only mention the above in case a further and more complete survey be undertaken at some future time.

The following is a list of the formations noted in the district under examination :—

1. *Tauranga Brown Sands.*
2. *Tawhiti Beds.*.—Marls and sands, with thin belts of hard sandstone and sandstone concretions, also a belt of limestone.
3. *Poverty Bay Oil Rocks.*—Shales, sandstones, and slates, very regularly stratfied, and lying at high angles.
4. *Slates and Sandstones.*—(Rimutaka series.)
5. Trachytes and trachitic agglomerates.

Tauranga Brown Sands.—Surrounding Opotiki, and stretching back to the Waireka Gorge, are certain brown sands, similar to those which appear at Tauranga and at various places between that point and Opotiki, and which Dr. Hochstetter has classed as "Diluvial pumice sands forming terraces," and placed them as Pleistocene as regards age. To the eastward of Opotiki these beds form a large flat table land, probably about three miles long by two miles broad, being bounded inland by the slates to be described further on. They are undoubtedly the youngest beds seen in the district under consideration, with the exception of a small extent of blown sands, and the river deposits; but, as far as I was able to ascertain, they do not yield any fossils.



Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S., DIRECTOR.

To illustrate Report by S. HERBERT COX, F.G.S., Assistant Geologist. May, 1877.

Tawhiti Beds.—The next youngest beds which are seen are those which Dr. Hector has named the "Tawhiti Beds" in his map, shewing the results of his East Coast trip in 1874, and I may be allowed to use the name here as applying to a further extension of them in this locality, as it will by that means render the future classification of these beds under general names more simple, the Tawhiti beds being now a definite horizon.

The greatest development of them which is seen is between a point a little to the westward of Wangaparau and Kawa Kawa, from which point they have been shewn by Dr. Hector as covering a considerable area of country inland.

This my present work quite goes to bear out, as, after leaving the mouth of the Whangaparau River and following the inland track, they are seen to expand greatly, as shown on the map.

Where these beds are first seen in Waihau Bay, and passing eastward, they consist of light-blue, sandy marls, with fossils (*Cucullæa*, *Tellina*, *Dentalium*, *Natica*, *etc.*), overlaid by sandy beds with hard sandstone concretions and bands. Their dip at this point is S.E., at an angle of 15°.

They occur pretty constantly from here until nearly reaching Wangaparau, where they are overlaid by the alluvial deposits of the Wangaparau River.

The blue sandy marls are the lowest beds seen in this series, and on the boundary of a Toi-Toi swamp, near Mr. Brown's the following sequence is seen, the dip here being S.E., at an angle of 9°.

1. Sandy beds with hard sandstone concretions and bands.
2. Limestones.
3. Blue sandy marls.

From the upper beds of this series I obtained, in addition to the fossils before mentioned, oysters, *Terebratella*, and a ribbed *Pecten*, probably *Pecten vellicata*, and others.

The blue marls are known here locally as "Papa rock," and I would call attention to the fact that this term is not applied to the *Leda* marls alone, but also to any greasy beds which at all resemble them, so that much confusion may arise from the name.

No very good sections of these beds are to be seen in ascending the Whangaparau River. They form undulating, fern-covered hills, rising to an elevation of as much as 500 ft., following the ridge of which the track has been made.

In the Waikohu River they appear up the greater part of the distance I travelled, this being from the beach to where the track leaves the river, perhaps eight miles altogether, but near the Wharekaika settlement I found an outcrop of the cretaceo-tertiary marls in the bed of the river, dipping N.E. at an angle of 35°, and overlaid unconformably by the Tawhiti beds above mentioned.

The Waikohu River brings down sandstones and calcareous slates, which doubtless belong to the secondary beds shewn by Dr. Hector as occupying the back country about here, and which reach the coast again before coming to Raukokore.

At a point between Te Kereu Creek and Kotiki Point an outlier of this formation occurs, consisting of a bed of limestone with included fragments of slate, and many net and branching corals, besides some other fossils which are very imperfectly preserved.

The limestone is overlaid by sandstone, about 150 ft. in thickness, the dip of the beds being N.N.E., at an angle of 30°. They are resting unconformably upon the slates which occur at this point, and occupy only a small surface area.

Poverty Bay Oil Rocks.—Between the last-mentioned rocks and the next which appear in the sequence (if we except a single outcrop in the bed of the Waikohu River of the cretaceo-tertiary marls, before mentioned) a great break occurs, and the next beds which we have to consider are the secondary rocks, which extend from Raukokore nearly to Whangaparau, and stretch inland towards Hikurangi, in all probability forming the mass of that mountain. On this point, however, I am only able to surmise, as I have never been nearly so far inland as there.

At a point just to the westward of Raukokore, where this series of rocks first makes its appearance on the sea coast, dark-coloured shales are seen, dipping S.E., at an angle of 20°, and distinctly overlying slate beds of the same series, and which dip at the same angle.

An anticline occurs in this locality, the axis of which runs about N.-S., and follows more or less continuously the direction of the coast line.

The beds which occur below the before-mentioned shales consist of certain sandstones and calcareous slates, with thin bands of shales or marlstones interbedded with them, the general strike of the beds being W.N.W., with a N.N.E. dip at an angle of 45°.

They extend uninteruptedly along the coast until nearly reaching

Whangaparau, and form a most marked feature on the coast, owing to the way they have weathered, the hard rocks standing up abruptly in slabs which are left in isolated positions, the interbedded softer shales having been the first to be eroded by the action of the sea. Altogether this would form a most dangerous coast for shipping if it were in a more exposed position; but in the Bay of Plenty, although a rough sea gets up with a N.E. wind, it is of but short duration.

These rocks probably belong to the oil-bearing rocks of Poverty Bay; but, as the highest bed of that series or cone in cone limestone is wanting in this locality and the other beds appear to be unfossiliferous, I cannot say that conclusive evidence exists with regard to their age.

In some of the beds I saw indistinct carbonaceous markings, and at certain places I noticed a tendency to concretionary structure in the sandstone.

The beds generally bear a marked resemblance to the higher portion of the Mataura plant beds as developed at the Waikato Heads, overlying the Putataka fossiliferous marlstones.

I have very little doubt that these beds are really the equivalents of the Mataura plant beds, but this, of course, yet remains to be definitely settled, and it will, I fear, be some time before the country is sufficiently opened up to allow of an exhaustive survey setting this matter completely at rest.

The Maoris at Raukokore informed me that there was coal in the locality, but on tracing the matter to its source I found that the rumour was quite unfounded, or rather arose from the fact that about ten years ago some man who was wind-bound off Raukokore came ashore and took some stone away with him from a point shown me by the Maoris, saying that he would come back soon to work it. He has not yet returned, and one of the Maoris told me that he thought he was either dead or else the stone was not any good.

The point from which the stone was taken exhibits nothing but hard slaty beds regularly stratified, and I could see not the least indication of petroleum shales even, which I at first supposed to be what they meant, so I conclude the Maori is correct in his surmise.

Slates and Sandstones (Rimutaka Series).—The oldest rocks seen in the district are the slates and sandstones which occur between Raukokore and Opotiki. These beds present no special characters worthy of note. They consist of sandstones, which form where unweathered a

hard solid compact rock, but they weather to a soft white and brown sand, sometimes to a considerable depth, giving one the impression when seen in slips from the distance that some younger beds are overlying the slates and sandstones, but a more careful examination of the character of the rocks at once shows that this is not the case, as all the stages of decomposition can be readily traced, more especially between Te Kaha and Opotiki, where at points cuttings have been made for the road which is now completed for that distance.

The slates themselves weather to a soft brown rock, very similar in character to many of the decomposed beds seen round Wellington, and I have no doubt that they are of about the same age.

The general strike of these beds is N.E., and they are standing nearly vertical at most places, although at points, as at Te Kaha, for instance, they are lying at much flatter angles. Their strike at Te Kaha is N.—S., and their dip east, at an angle of 30°.

A belt of slate conglomerate comes in at the same point where the outlier of the Tawhiti beds before mentioned occurs, and regularly interstratified with the slates and sandstones at that point.

Trachytes and Trachytic Agglomerate.—The last rocks which require mention are the trachytic rocks, which occur along the coast line between Cape Runaway and Hick's Bay. Crossing the coast range from the inland track, no outcrops of rock are to be seen, and it is not until reaching the creek which runs into the sea at Okarae that the trachytes first make their appearance. On reaching the sea coast these trachytes are seen to be solid flows, having been worn by the sea into long flat reefs, which are traversed by fissures running back to the cliff.

These fissures are sometimes of very considerable depth, and are at points extremely difficult to get round. They have probably been caused in the first instance by the cooling of the trachytes, and subsequently by the action of the sea, which beats with great force against this rocky coast.

The trachytes in solid flows may be observed continuously until nearly reaching Matakaua Point, Hick's Bay, where they pass by degrees into a coarse angular agglomerate, and continue as such into Hick's Bay.

I could see no point that I could refer the centre of eruption to here, and think that such a centre was in all probability to seaward, as, until reaching the Motu country, it is unlikely that

any further development of these rocks would be met with inland. They appear to me to be of the same age as the trachytes of Wangarei Heads, which they resemble in a marked degree, and as they are overlaid by the oyster bed which, is the lowest member of the Tawhiti series, as here developed, they must be, at least, of upper Eocene age.

SUMMARY REPORT OF COAL EXPLORATIONS, AUCKLAND DISTRICT,

To accompany Maps and Sections.

BY R. B. DENNISTON, COAL VIEWER.

May, 1877.

I HAVE the honor to report that, as instructed, I have examined and collected from the strata exposed in the valley of the Waikato River, from Mercer to its mouth, thence along the coast line to Raglan; thence inland (eastward), crossing the Kapamahunga Range into the Upper Waikato and Lower Waikato Delta, till again reaching Mercer.

From Mercer I was instructed to explore round the Lower Delta of the Waikato, along and under the south slopes and base of the Pukehohe Ranges towards the Miranda Firth of Thames; thence southward along the west slopes of the Maunga Kauri Ranges (forming the east side of the Delta), and westward under the north slopes of the Taupiri Ranges, crossing the Waikato River at *Ralph's* and *Kupa Kupa* coal mines, and thence northward under the east slopes of the ranges, forming the west side of Delta till gaining Mercer, taking the centre of the Delta where practicable, and examining the various going collieries at present working in the Lower Waikato Delta, *viâ Bridgewater* (Foote's), *Rahuipokeka* (Ralph's), *Kupa Kupa* (Whitaker and Russell's), under lease to the Waikato Steam Navigation and Coal Mining Company.

This being completed, the *Wangarei* coal field, so far as time would allow, was examined, embracing part of north side of harbour, *Awarua Valley* (Dent's property), *Whareora*, *Kamo* (Meldrum's), and *Whau Whau*. Coal outcrops were also traced to and round *Hikurangi* towards *Kawa Kawa*, Bay of Islands. The results obtained will be found noted in detail, together with sections of strata where these could be obtained, and maps of the districts covered, showing the probable areas over which coal exists. Sections and working plans of the various collieries visited are also appended.

Waikato Lower Delta, Mercer.—Round this district, especially in the cuttings laid bare by the construction of the Auckland, Mercer, and Waikato Railway, reaching from Pokeno to Mercer, and along the

banks of the Waikato River to the mouth of the Wangamarino River, sections of the strata are laid bare, showing for the most part soft yellow sandstones, interstratified with thin bands (bars) of compact sandstones and shales, below which marls (*Leda* marls) containing fossils occur.

The strike of the measures along the river bank is east and west, and they appear to hold regularly, with the exception of a few minor faults seen in places along the face, as may be seen from Sections Nos. 1 and 2 and general Section A.

Tunnel Mouth, Mercer.

		ft.	in.
Section No. 1	Soft yellow sandstone - - - -	20	0
	Marls to level of railway - - - -	60	0
		80	0

Dip, S. 3°

Near Junction of Wangamarino Creek.

		ft.	in.
Section No. 2	Soft yellow sandstone with hard beds - -	35	0
	Soft sandstone with bands of shale, to road level - - - - - - - -	60	0
		95	0

Dip, S.E. 3°

Along this line the general dip is south till reaching the junction of the Whangamarino Creek with that of the Waikato River—a point distant from Mercer about one and a half miles, where the measures are observed to dip S.E., and show a general indication to basin south and eastward under the Delta.

Northwards from Mercer towards Pokeno (Queen's Redoubt), and at the base of Pukekohe Ranges towards the crop, the same formation holds, though undulates, as seen along the railway cutting, likewise exposing a few small faults, till, reaching a distance of about (2) two miles, or about half a mile distant from Queen's Redoubt (Pokeno,) in one of those hollows or depressions soft grit measures are observed to overlie on the soft sandstone. Further north towards base of Pukekohe Range these measures are observed to be overlain by volcanic formation, which holds to the heights of the range.

Eastward from Mercer Railway Station, crossing an undulating country, a small extinct volcano is met with, showing on the terrrce heights to east of same. Grit measures on the face of hill dip south 3°, while further east the same grits are observed overlaid by clay.

On Heights round Mercer.

		ft.	in.
Section No. 3	Surface		
	Clay	20	0
	Soft grit	18	0
	Coal, lignite	1	0
	Soft grit	30	0
	Soft yellow sandstone		
		69	0

Dip, S.E., to all appearances overlying the lower or Mercer beds

Further east, crossing undulating though falling country, the same soft sandstone shows midway up the spurs, in places overlaid by soft grit, which holds till nearing the swamp land, under which the measures appear to basin, dip S.E., 5°, and in the area of this swamp a narrow peninsular or terrace is met with, exposing soft grits (dip south) near the edge of the swamp (in caves which occur in these beds Maori bones are found in quantity); from this point eastward swamp land holds till reaching well to the east side of the Delta, where high land is met with, and at the base of this hill.

Bridgewater Colliery (Foote's), a going colliery, is situated at the edge of a swamp, the coal here (pitch coal), 54 feet thick, being wrought by a shaft which is sunk 66 feet below the level of the swamp, as in the section below :—

Bridgewater Shaft.

		ft.	in.
Section No. 4.	Surface	1	0
	Leda marls }	16	0
	Fire clay }		
	Dark sandstone	2	0
	Coal pitch)	55	0
	Shale	2	0
	Blaze		
	Shale not buttoned	76	0

Dip, N. 5°.

The winning of the coal here, being only recently commenced, is being opened on a system of ordinary square work. The level heading south from the shaft has, as may be seen from the plan of the workings accompanying the report, reached a distance of 80 links. This level from its bearing reaches out under the swamp, and for the present Mr. Foote, the proprietor, has judiciously discontinued its extension, fearing that the overlying strata to the surface of the swamp, fire-clays and marl being soft, may allow of surface drainage to the detriment of the mine.

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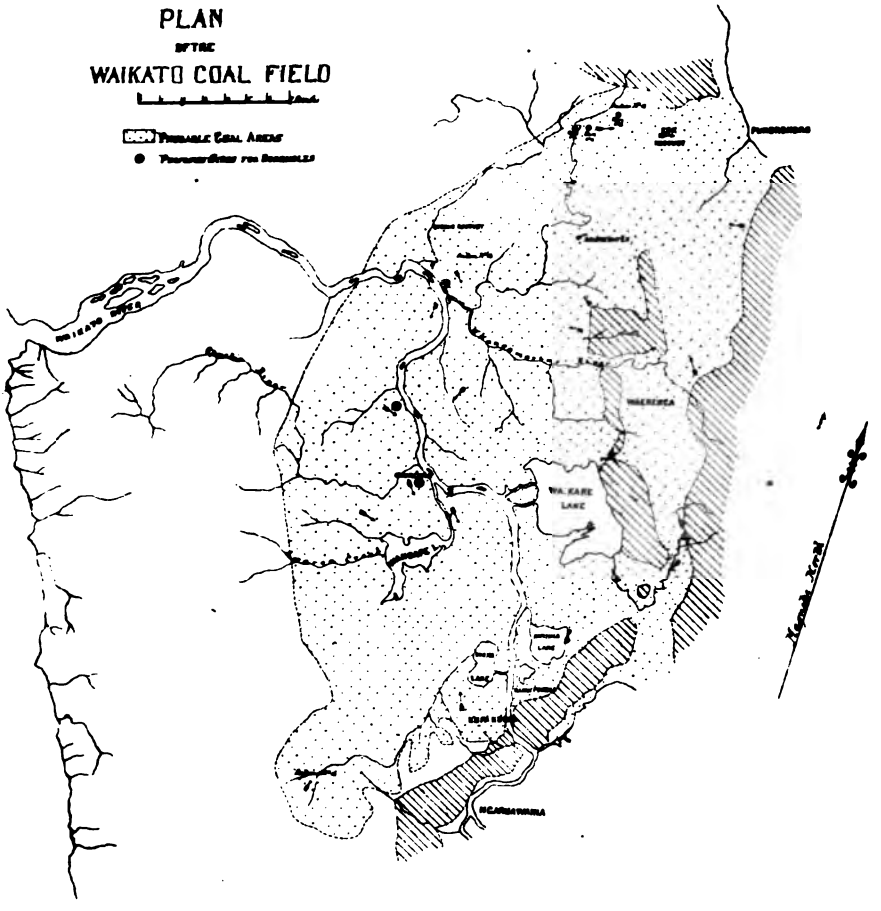
To illustrate Report by R. B. DENNISTON. May, 1877.



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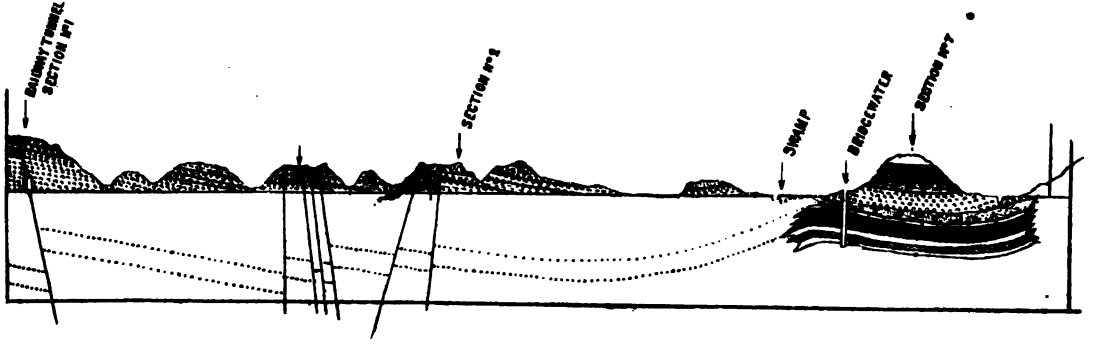
WAIKATO COAL FIELD

SECTION

FROM

MERCER TO BRIDGEWATER.



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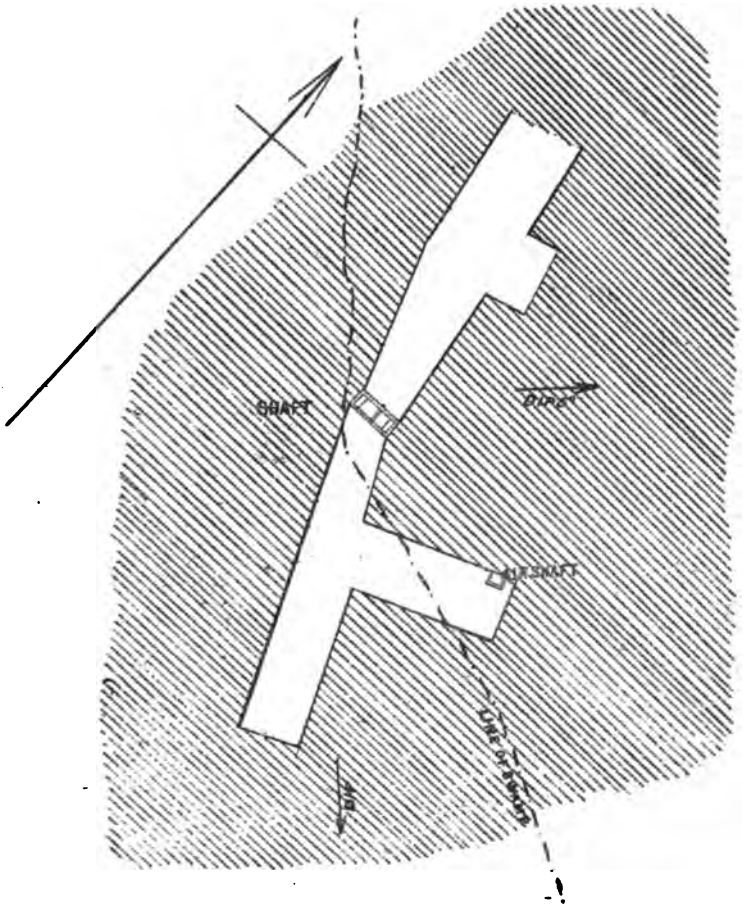
WAIKATO COAL FIELD

PLAN

OF THE

BRIDGEWATER COLLIERY.



The opposite level, bearing N. 10° E., up to date had been driven for a distance of 79 links, bearing under the weight of the hill, and may be said to be the main permanent level for future safe workings.

This pitch coal so far as driven into shows to be clean, compact and comparatively free from sulphur; it is freely bought up locally, the the demand being equal to the supply.

The output from this pit I found to be limited—about 60 tons per week, though the workings are in a position to allow of a much larger output, and of considerable lasting extent.

The mode of transport of this mineral from the mine to the market is along a *tram* for a distance of 55 chains, where it is loaded into small barges and conveyed down the Kopuku Stream, a long, winding, and all but unnavigable stream, through swamp (workable only to advantage in a flooded state) for a distance of 3 miles to its junction with the Mangatangi River, a deep stream, (distant from the mine in a straight line 35 chains), hence down the Maramarua and Wangamarino Rivers to the Waikato, a distance of 16 miles, where it is loaded into railway trucks at the railway depôt, Mercer, Waikato River.

While here, my attention was drawn by Mr. Foote to the fact that by a canal cut from near the junction of the Kopuku Creek with the Mangatangi River, distant about 35 chains across the swamp from the pithead, would, if undertaken, enable him to probably double his output, and lessen the present cost of handling the coal, and consequently, materially lessen the cost of the coal to the consumers. This would doubtless be the case, and Mr. Foote is only kept from carrying out this work by want of funds, having exhausted his capital in prospecting his ground.

On the rising ground to the east and north-east of this shaft numerous small shafts have been sunk, varying in distance from 10 to 80 chains from the present workings, the most important of which are given in the sections below:—

About 10 chains, N.E., from Bridgewater Shaft.

		ft.	in.
Section No. 5	Surface	1	0
	Plastic clay and sand	8	0
	Ironstone	0	8
	Fire-clay	15	0
	Dip, N.E.	26	8

Behind Foote's Residence, Bridgewater Colliery.

		ft.	in.
Section No. 6	Surface	1	0
	Marls (leda)	11	0
	Ironstone (stratified)	0	8
	Fire-clay	11	0
	Ironstone (stratified)	0	8
	Fire-clay	11	0
	Ironstone (stratified)	0	8
	Coal	0	2
	Fire-clay (not bottomed)	0	6
	Dip N.E.,	36	8

shewing overlying strata of fire-clay and bands of stratified ironstone intermixed with the *Leda* marls, samples of which have been already forwarded.

These sections, when carried on to the crown of the hill from the mouth of the shaft, show 151 feet of overlying measures, and on the whole a full thickness, including the shaft measures to bottom of coal 227 feet, which will give a sequence as follows:—

Sequence of Bridgewater Measures.

				ft.	in.	
Section No. 7.	Surface clay					
	Soft yellow sandstone			80	0	
	Leda marls			30	0	
	„ ironstone			0	8	
	„ fire-clay			11	0	
	„ ironstone			0	8	
	„ fire-clay			11	0	
	„ ironstone			0	8	
	„ coal			0	2	
	„ fire clay		6 0			
	„		11 0	17	0	
				151	0	Base of hill, level of swamp.
	Fire-clay and marl		17 0			
	Dark sandstone		2 0			
	Coal (pitch)		55 0			
	„ shale		2 0			
	„ blaze					
	„ shale (not bottomed)			76	0	Depth of shaft.
				227	0	

Continuing N. and N.E. from this colliery the same measures are seen to hold regular with an apparent dip N.E., till reaching at a distance of about 2 miles in a straight line, the crossing of the Mangitangi Stream, Muir's Farm, in the banks of which a pebble bed covering is observed, though with an altered dip S.W. Westward from this, towards and past *Dow's Homestead*, "*Kerepuka*," and further west about a mile reaching the Pukeotoha Hill, where a section is seen as follows :—

Pukeotoha.

		ft.	in.
Section No. 8.	Pebble beds	60	0
	Tufaceous beds	90	0
	Pebble beds	10	0
	Tufaceous beds, intermixed with chert nodules to edge of swamp	200	0
		360	0

Dip, W. to S.W.

Following this ridge to the dip for about 2 miles, until gaining the Mangitangi Stream, at a point where the telegraph line crosses the creek under the base of the Surrey Ranges; this tufaceous formation is seen to be underlaid by a pebble bed belt, which here forms a roof over a thin seam of lignite, the general dip being S.W. to S., or inclined to dip towards Foote's, though flanking the Pukokohe Ranges, under the Paparata and Mangatawhiri Valleys, towards Mercer.

N.E., under the base of the Surrey Ranges, the measures alter in dip to N. and N.E., and generally shew indications of basining towards the Miranda, under the *English Companies Lease or Whare Kawa Block.* The work undertaken by this company, up to the present, has only extended to the sinking of a few trial shafts and bores. One of these shafts, situated under the base of the Surrey Redoubt, a distance from last point N.W. about 2 miles, giving the following section :—

English Company's Shaft, under Surrey Redoubt.

		ft.	in.
Section No. 9.	Surface (clay)	7	0
	Dark brown sandstone	1	0
	Dark parting	0	6
	Coal (pitch)	9	0
	Shale (not bottomed)	1	6
		19	0

Dip, N.E. to E.,

shewing somewhat similar measures and coal to that gone through at (Foote's) Bridgewater Shaft.

In a N.E. direction to the dip this company has placed bores, which I give as supplied to me by *Mr. Lowe, C.E.*, the then superintendent of these works.

English Company's Bore, No. 1.

Section No. 10.

	ft.	in.
Surface Soil	2	0
Mottled clay	23	0
Ironstone boulders with sand and water	6	0
Strong blue clay	15	0
Strong sandstone	16	6
Strong blue clay	40	6
Pink clay	20	6
Green sandy cement	24	6
	148	0

Bore here stopped for want of rods.

English Company, near Section No. 9, Surrey Redoubt, Bore No. 2.

Section No. 11.

	ft.	in.
Dark chocolate-coloured clay		
" " " " in creek bed	5	6
Coal	0	6
Fire-clay with patches of *coal*	8	3
Fire-clay	9	3
	23	9

English Company's Bore, No. 3.

Section No. 12.

	ft.	in.
Surface soil	2	0
Light green clay	8	0
Dark green cement	6	6
Fire-clay	9	6
Blue sandy clay or marl with thin clay bands	26	0
Fire-clay	4	9
Blue sandy clay or marl with thin clay bands and nodules of chert	19	0
Chocolate fire-clay with pieces of coal	3	6
Lead-coloured calcareous sandstone	1	3
	80	6

Here stopped by order of the Directors of the Company.

From here eastward the country indicates that of a basin-shaped area, with overlying tufaceous beds towards the Miranda, and I should be of opinion that this company, if they had continued any of their bores to a greater depth, would have been successful in cutting the

continuance of the seam of crop coal to the dip which was cut in the trial shaft Section No. 9 to crop, as the measures generally indicate to basin eastward through this hollow country towards and under the Miranda, being confined by the Pukekohe ranges to the N.W., and the Maunga Kauri Ranges to the S.E., which latter Range, consisting mainly of slate, forms the eastern boundary of the Waikato Delta.

Along the west slopes of this range I have been informed by Mr. McGlynn (Mr. Foote's underground manager) that coal has been observed to crop up in places near the Miranda. So far as I have traversed along the foot of the hills southwards the coal measures show, exposing soft yellow sandstone and marls, with a general dip west. Southwards and out into delta towards Foote's, though in places holding a covering of volcanic beds, the coal measures appear to hold regularly along the flanks of this range, crossing the head waters of the Wangamarino stream (Waerenga settlement), till reaching the head or N.E. end of the Delta (Mataruru Stream), as they form a narrow trough-shaped area, confined by the east slopes of Kopuku Ridge, about one mile south from Bridgewater Colliery; and that of a slate ridge (name unknown) holding along the east side of Waikare Lake to the Mataruru Stream, north end of Delta.

At the north and N.W. base of this Kopuku ridge numerous trial levels have been sunk by Mr. Foote here, showing the coal to crop a few feet under the level of the swamp in thickness varying from seven to ten feet, dip N.N.W. and W., and to further lap on to slate. In a few places along the west base of this slate ridge near the edge of the swamp several outcrops of coal show, lapping on to the slates, and south also till reaching the Wangamarino Stream, with a general dip west under swamp.

Southwards, along the west slopes of the ridge, on the east side of the Waikare Lake, the strata consists of clay slate to the edge of the water, this formation holding south till reaching the mouth of the Matururu Stream, south point of this ridge, where the coal (lignite) formation shows at the base, being probably the continuation of the Matururu Valley coal measures. The general dip is northwards under the delta and the measures generally indicate to hold westward along this northern end of the Delta, flanking the Taupiri Ranges.

Along this line the overlying measures *Leda*, marls and brown sand-

stone show along the base of the range, dipping north, until reaching Rimihia and Hakanoa Lakes, where coal outcrops are exposed at the water's edge, and are traceable westward till reaching

Rahuipokeka (Ralph's) Mine.—This is a going colliery on the east banks of the Waikato River and railway, at the base of the Taupiri Ranges, and is being wrought by a tunnel entered in the side of a spur upon a system of square work with no regularity, as may be seen from the plan. A section of the tunnel mouth shows as follows :—

Tunnel Mouth Ralph's Mine.

		ft.	in.
Section No. 13.	Surface		
	Plastic clay (broken and scorched)		
	Leda, marl and fireclay - - - -	10	0
	Coal (pitch) - - - - -	18	0
		28	0

Dip, N. to N.W. 5°

This coal (18 feet thick) seems to be the same seam as that being wrought at Foote's. Since I visited this mine I have been informed by the proprietor that having sunk on the then floor of the coal a further thickness has been proved, shewing :—

		ft.	in.
Section No. 14.	Band of blaze - - - - - -	3	0
	Coal (pitch) - - - - - -	13	0
	Fire-clay		
		18	0

Outcrops of coal are obtained along the banks of the river southwards into the gorge and up the slopes of the mount, indicating an apparent thinning and elevation in dip. The measures lapping on to the base of the Rangiuru Peak, which here shews slate to the surface strike N. and S.

Eastward from the river, along the heights of these hills, slate is seen holding, and near the base of the range the coal formation is observed, exposing in places ironstone and fire-clay on the spur sides, likewise the underlying pitch coal which crops out in the low ground along the banks of the Hakanoa Lake, where the top of the coal only is seen. The dip is N. to N.E. 12°. Between this point and the river, to the westward, numerous coal outcrops are exposed by drives and grit pits sunk by the proprietors of this mine, all showing the upper measures much broken and in places scorched by volcanic action in the close proximity of the

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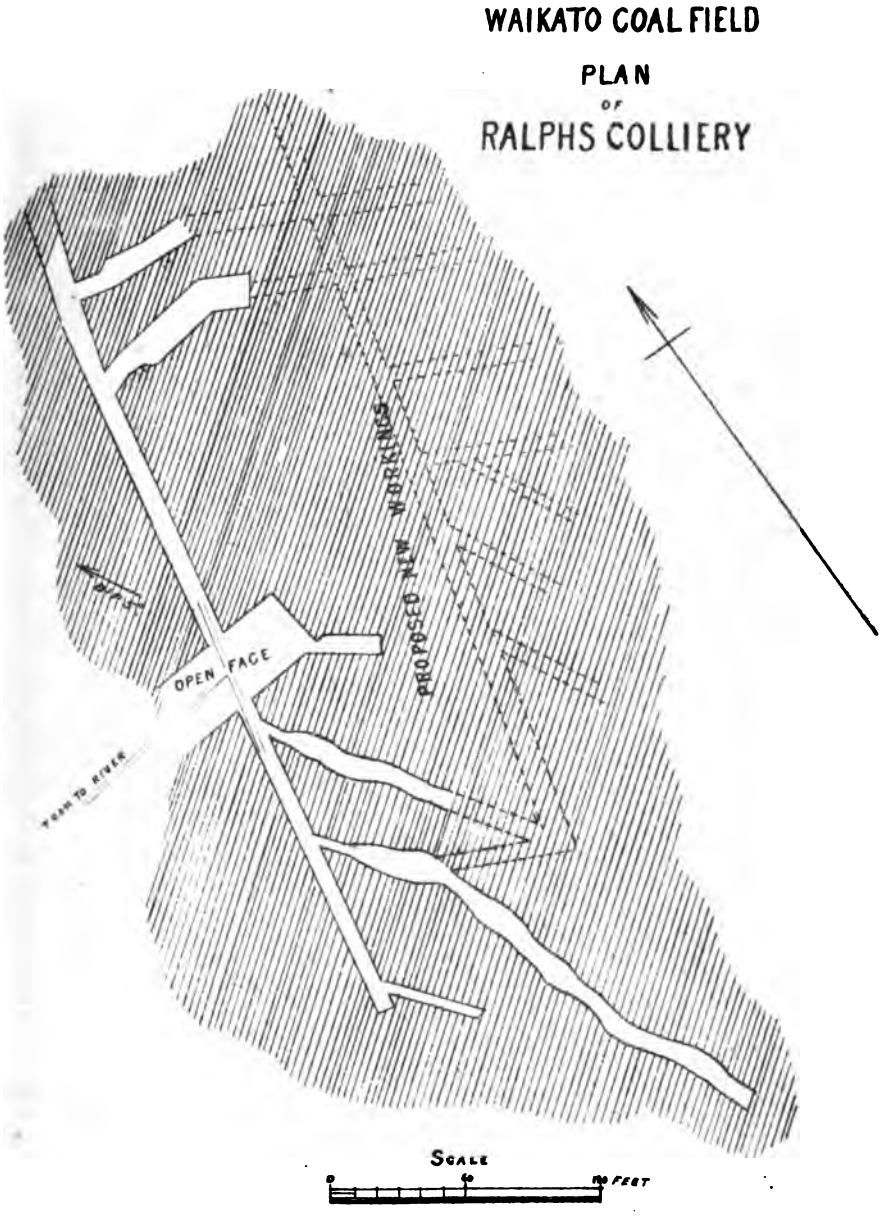

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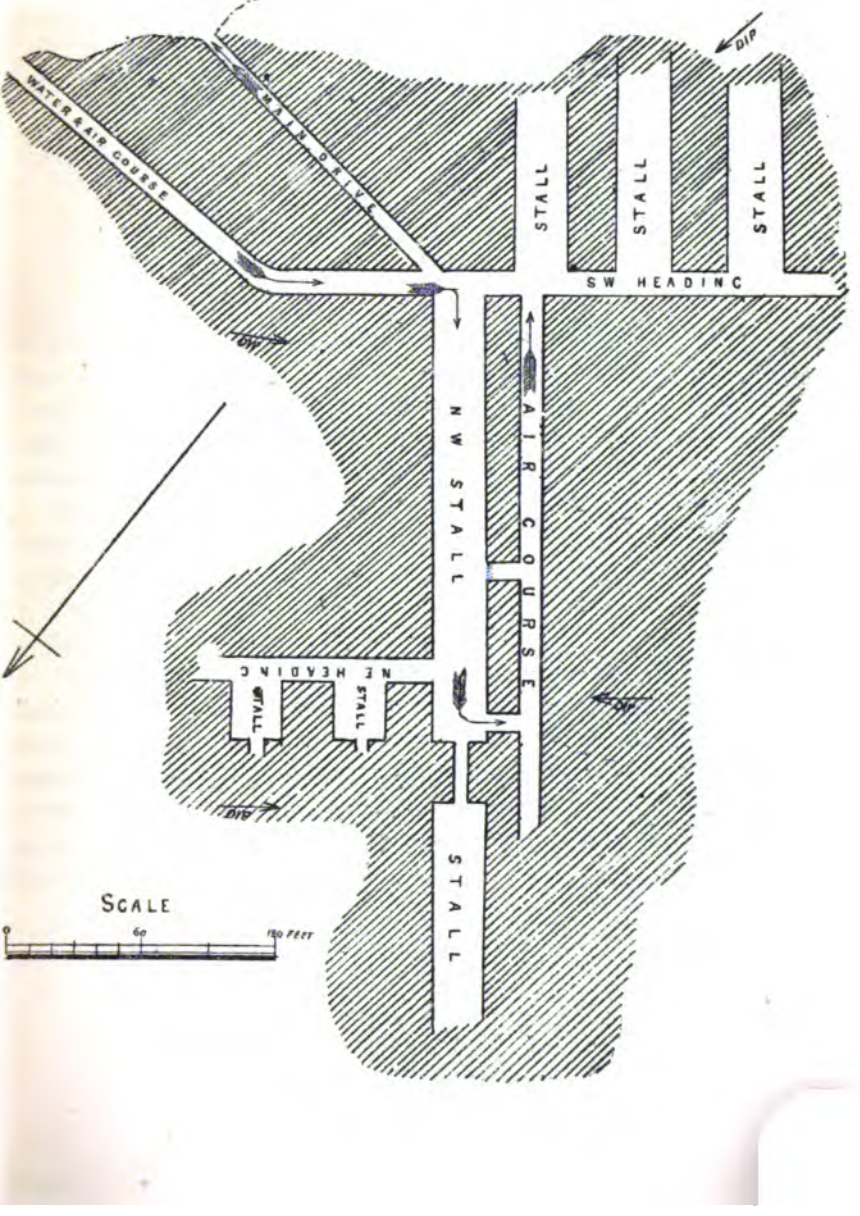
WAIKATO COAL FIELD

PLAN

OF

KUPAKUPA COLLIERY



coal, which, however, shows throughout to be sound, holding an easy dip north, N.W. and N.E., from 5° to 10°. The coal has been traced northwards to the level of the river, and generally the measures indicate to hold northwards under the Delta.

Kupa Kupa Mine.—On the west side of the Waikato River a going Tunnel Working is opened on the heights of the hill. The tunnel is entered on coal 130 feet above the level of the river, and about 100 feet higher elevation than that of Ralph's coal, indicating an upthrow fault to the westward. Between this tunnel mouth and the river the following section is obtained :—

Section of Kupa Kupa Mine—Tunnel Mouth.

		ft.	in.
Section No. 15	Surface	3	0
	Soft yellow sandstone, laminated	17	0
	Coal (pitch)	18	0
		38	0
	Shale		
	Blaze		
	Shale		

Dip, N. 5°.

This coal is seen to be a continuation of the seam in the east side of the river (Ralph's Mine), and is wrought under the management of Mr. James Dunn upon a system of square work, and may be said to be in highly satisfactory order. A plan of the workings will be found herewith appended, showing the workings on a true system of post and stall.

The main heading upon entering the tunnel shows the coal and measures to undulate slightly, working into small trough basins, though on the whole it strikes east to west, having a general dip north and N.E. towards the Wahi Lake and under the Delta, and should prove a working of considerable and lasting extent.

Westward from this mine the overlying measures of the coal formation—soft yellow sandstone, fire-clay, ironstone intermixed with *Leda* marls, and coal outcrops—are traced through an undulating country till reaching west towards Raglan, on the Waka Whau Whau Creek, on the range to the west side of the Delta (the furthest west point gained). Here coal outcrops were shown to me by natives at the head of the Awaroa Creek, reading as follows :—

Waka Whau Whau Track, west side of Delta.

		ft.	in.
Section No. 16.	Cobden limestone		
	Space—measures not obtained		
	Soft yellow sandstone		
	Fire-clay and Leda marls		
	Soft laminated sandstone - - - -	20	0
	Coal (pitch) - - - - - -	10	0
		30	0
	Blaze		
	Dip N. 5°.		

Extending north along the line of range on the west side of the Delta, the limestone formation appears to hold regular along the heights in a northerly direction across the Awaroa River (Wangape Lake) and Opuatia River; while in the low country at the base tufaceous beds show, and appear to hold the greater part of the distance north in the area till reaching Wangape Lake, where the *Leda* marls show along the south bank in sectional faces, being in places overlaid by soft yellow sandstone and lignite grits.

Working east along the north bank of this lake the same strata appear until reaching Churchhill, on the Waikato River, and further to the eastward they appear to be regularly bedded along a ridge, reaching along the centre of the Delta from Rangiriri northwards towards Mercer.

In the upper end of this ridge there is a point known as Thompson's Pa, at the base of which, near the edge of Waikato River, on the east bank, lignite measures show, exposed in sectional face as under :—

Thompson's Pa.

		ft.	in.
Section No. 17.	Soft brown grit - - - - - -	20	0
	„ white „ - - - - - -	5	0
	Coal (lignite) - - - - - -	2	0
	Shale - - - - - - - -	3	0
	Soft sandstone - - - - - -	2	0
		32	0
	Leda marls		
	Dip, S.E. 5°.		

The indications in this locality appear to show that these measures hold to the east and north in this ridge, as in following a course about on the line of the strike of the measures the lignite seam is observed to crop along the line of the main south road, and from general indications I am of opinion that it holds steadily on these heights towards Mercer.

From the Opuatia River on the west side of the Waikato River, bearing northwards towards Mercer, and under the flanks of the range, along a somewhat broken country, soft yellow sandstone and marls are seen exposed in places with a dip to the east, and they appear to hold regular to *Punga Punga*, where, about midway up the heights, the lignite measures are obtained overlying them, showing as follows :—

Punga Punga.

Section No. 18

	ft.	in.
Surface		
Soft grit	32	0
Coal (lignite)	14	0
	46	0
Shale		

Dip, E. 3°.

This formation holds the entire distance northwards till reaching Mercer. No coal has been observed to crop, but from general indications I should be inclined to think that these lignite beds hold steadily along this country on the heights, as midway along the spurs to low ground the underlying strata, soft yellow sandstone and marls, show exposed in most places well bedded.

Here in the area overlying Mercer my labours were stopped by the natives, who refused to allow me to further prosecute my explorations.

I have since been informed that on this native ground, in a well sunk by Major Te Whero's brother, in the low ground near river, into marl and fire-clay, at 40 feet, they passed through a band of stratified ironstone. This information was supplied to me by Mr. R. Hunt, of the Waikato Steam Navigation Company, and I presume that it is reliable.

REMARKS.

The beds at Mercer, *Leda* marls overlaid by soft yellow sandstone (Section No. 1 and 2), holding on the heights a covering of the lignite formation (Section No. 3) have been traced to hold regularly eastward along this Delta area and to basin under the swamps till reaching Bridgewater Colliery, where a similar sequence of measures to those of Mercer are seen (as in upper part of Section No. 7). Further sections of the underlying measures are obtained, as in Sections No. 5 and 6, showing bands of stratified ironstone and fire-clay intermixed with the *Leda* marls, and underlaid by fire-clays and marls to the pitch coal, as in Bridgewater Shaft, Section No. 4, on the whole a sequence similar to

that given in Section No. 7, giving the full readings of the measures from the soft yellow sandstone to the coal. A similar sequence of the coal measures may be reasonably expected to underlie the Mercer beds.

From Bridgewater Colliery the same measures hold regular, with an apparent dip N.E., crossing the Mangatangi Stream under the Surrey Ranges, at which point the lignite formation is seen overlaid by tufaceous beds (Section No. 8); dip, W. to S.W., basining towards Foote's the Bridgewater Colliery, and under the hills to the foot of the Pukekohe Ranges west towards Mercer.

From this point to the north and east the measures seem to take a reverse dip N.E., which holds until reaching under the Surrey Redoubt, where the underlying measures show, as in Section No. 9 (a shaft sunk on the Whare Kawa Block or English Companies lease), cutting pitch coal nine feet thick, similar in quality to that of Bridgewater Colliery, the reading of this section being similar to that of the Bridgewater shaft, Section No. 4.

To the N.E. of this trial shaft and to the dip of the coal three bore-holes have been put down through strata shown in Sections No. 10, 11, and 12, the readings of which, as far as they go, indicate that they were put down through the upper measures; and, if carried on to a greater depth, it would have been more than probable that coal would have been cut, as from here to the eastward the lay of the country indicates to be that of a basin-shaped area, holding a covering of tufaceous beds, as in Section No. 8, and I am of opinion that the pitch-coal formation will be found to underlie these measures, and to basin towards the Miranda Redoubt, Firth of Thames.

From the Miranda southward the coal formation has been traced holding along the foot of the hills of the Maunga Kauri Ranges (west slopes), and along the low country confined on the west by the east slopes of Kopuku Ridge and Waikari Lake Ridge, on both of which slate shows to the surface, and indicates that a narrow though trough-shaped coal area occurs, reaching to the upper or south end of the Delta through the Wangamarino Valley, part of the Waerenga settlement, and the Matururu Valley to mouth of stream of same name.

Out in the Delta on the north, N.W., and west base of the Kopuku slate ridge numerous outcrops of coal are obtained at the level of the swamp, in thickness from 7 to 10 feet, and they generally show the coal

to dip west under the swamp. The coal is also traceable along the west base of the ridge, at the level of the swamp, until nearing the Wangamarino Stream.

From this point north along the banks of the Waikare Lake slate only is traced until approaching the mouth of the Matururu Stream.

Westward along the south end of the Delta, towards the Waikato River, *Leda* marls and coal outcrops are traced along the foot of the range, which crosses the Waikato River at Ralph's and Kupa Kupa mines (Sections No. 13 and 15) to west side of the Delta. The whole general dip of the coal and overlying measures is towards and under the Delta.

The same indications continue to hold northwards along the west side, showing the marls and lignite formation to dip eastward towards the centre of the Delta, the same dip holding northward until again reaching Mercer.

The above data indicate that the coal measures basin from Mercer to the eastward, under the Delta towards the Bridgewater colliery, at which point similar beds to those occurring at Mercer are obtained, with a further continuance of the section in Foote's shaft down to the pitch coal, and a further continuance of the coal measures has been traced north and N.E. through the Wharekawa Block towards the Miranda Redoubt.

From this I think I am justified in concluding that the ironstone, fire-clays, and pitch coal, with the *Leda* marls, underlie the Mercer beds, and hold continuously from Mercer under the Delta to Bridgewater, the Wharekawa Block, and the Miranda Redoubt.

A continuance of the same coal measures has been traced along the base of the Maunga Kauri Ranges in a narrow trough-shaped area, probably holding an underlay of coal, outcrops of which are known by the natives in the Matururu Valley.

Outcrops of the same seam of pitch coal are observed to crop on to slates at the west base of Kopuku Ridge, with a general dip west under swamp area; the *Leda* marls or overlying measures of this pitch coal being traceable through most parts of the Delta area, in places capped by lignite formation. The whole generally indicates that the pitch coal underlies basined the width and length of this Delta area, from Mercer, Bridgewater and surroundings southwards to the upper end of the Delta

at Taupiri, where Ralph's and the Kupa Kupa Mines are situated. The coal now wrought in those collieries appears to be the southern outcrop of the Bridgewater Basin, as the sequence of the beds at the north end and in the centre read similarly to those at the south end of the Delta.

The truth of the above assertions, which are made from surface explorations and the comparison of sections at various points where obtainable, could best practically be tested by placing a bore at a site in this area where the shallowest points of the *Leda* marls could be found.

As a suggestion for the placing of this work three points may be chosen as being probably the shallowest sites, viz., to the westward of Churchhill, near the edge of the swamp of the Opuatia Creek; Punga Punga, near the Waikato River; and the tunnel mouth at Mercer, at any one of which points if a borehole were put down and the coal cut, the existence of coal throughout the area would be practically proved.

This work would be undertaken at a comparatively small cost, the measures to be passed through being soft, if, as is probable, a similar sequence to that obtained at Bridgewater Colliery, Section No. 7, be passed through.

From inquiries made from other practical men while I was in the district, I ascertained that the work would be undertaken at the following sliding prices, with the use of borrowed plant :—

1st	100 feet	- - - - -	7s. per foot
2nd	„	- - - - -	9s. „
3rd	„	- - - - -	12s. „

And a proportionate sliding scale to any depth not exceeding 500 feet.

One seam of pitch coal is at present wrought in the various collieries in this district, no lower seam having yet been traced beneath the known outcrops of the coalfield, probably attributable to the pitch coal measures overlapping unconformably on to the slate, preventing any lower measures from cropping, I think it probable that lower seams exist beneath this basin area, which will doubtless be proven in time by future mining enterprise.

WANGAREI.

Round this district part of my time was occupied in accompanying Mr. Cox on his geological work, taking the leading points of the district,

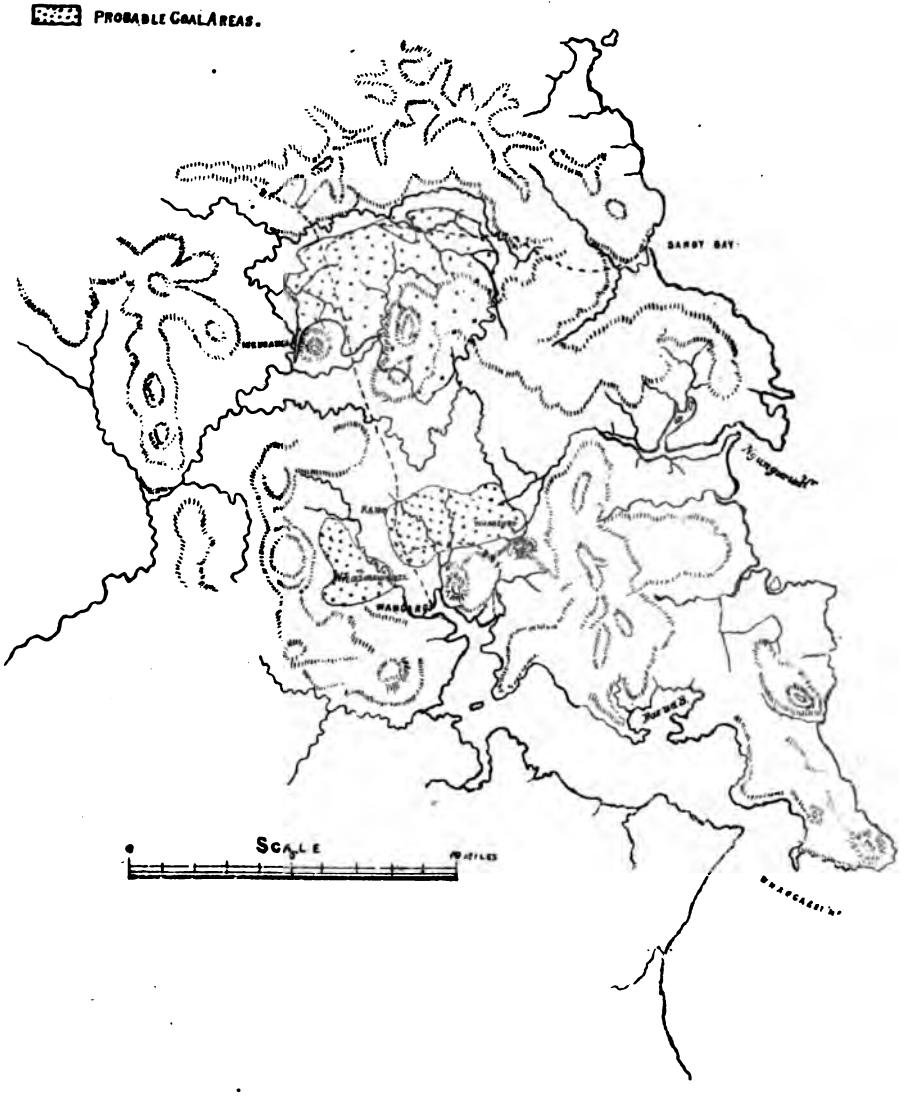
Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S., DIRECTOR.

To illustrate Report by R. B. DENNISTON. May, 1877.

PLAN

WHANGAREI COAL FIELD



likewise the few known coal outcrops and going colliery workings, viz., Whau Whau Colliery (Walton's lease), Kamo Colliery (or Meldrum's outcrop), Whareora and Hikurangi coal outcrops; also Mr. Samuel Dent's property, near where the Awaroa Creek falls into the Wangarei Harbour, about three miles west from the township of Wangarei.

Over these areas I have since extended my labours, tracing the extent of the coal so far as practicable from surface indications.

Samuel Dent's Property, Awaroa.—This area, covering part of the southern slopes to the base of Mount Tiger, is of itself a small hollow-shaped area, exposing along the surface of the area soft brown sandstone, underlaid by green sandstone.

On the area four bores have been placed by Mr. Dent, the greatest depth reached being 231 feet, sectional readings of which I give as under, as supplied to me by Mr. Bedlington, C.E., the then superintendent of these works:—

	No. 1 Bore.	Thickness.		Total Thickness.	
		ft.	in.	ft.	in.
Section No. 19	Strong yellow clay	3	0		
	Strong brown sandstone with minute shells - -	49	0½	52	0½
	No. 2 Bore.				
Section No. 20	Alluvial soil - - - -	4	6		
	Brown sandstone with small shells - - - -	141	9	146	3
	Black metal band - - -	0	2	146	5
	Hard brown sandstone - -	46	11	193	4
	Hard limestone band - -	0	4	193	8
	Soft blue clay - - -	0	2	193	10
	Brown sandstone with quartz crystals - - -	37	11	231	9
	No. 3 Bore.				
Section No. 21	Soil and clay - - -	4	10		
	Green sandstone - - -	33	2	38	0
	Hard band - - -	0	4	38	4
	Green sandstone - - -	3	10	42	2
	Hard ironstone band with partings - - -	6	6	48	8
	Hard ironstone conglomerate	0	11	49	7
	Hard limestone conglomerate	14	0	63	7
	Soft white limestone with hard bands - - - -	16	0	79	7
	Hard blue limestone - -	5	1	84	8

No. 4 Bore.

Section No. 22	Soil and clay - - -		7	6	
	Brown sandstone altering in shades from light to dark	100	5	107	11

The east side of this area is confined by a slate ridge holding northwards up the slopes of Mount Tiger, and likewise passing west along the north bank of the Whangarei Harbour. It is traceable in places, and from general indications would appear to hold, forming the east slope of the Parahaki Range, which forms the west side of this Awaroa Basin, being topped by tufaceous beds.

In various places in the hollow ground near the west side of this area limestone is observed; and, so far as my explorations have extended, I have been unable to trace definitely the underlay of the same.

Along the south slopes of Mount Tiger, or north side of this basin, no coal outcrops have yet been traced. Soft brown sandstone, underlaid by green sandstone, holds regularly on the surface, from the creek beds to the top of mount, with a general dip S.W.

On nearing the heads of some of these creeks water-worn slates are seen, but no solid face has been observed; likewise, in places, the soft sandstone shows in detached masses, from which I am of opinion that the sandstones on these heights is resting upon the slates.

Should further labour be expended in proving the mineral in this area (which, probably, would be done by boring), I should be of opinion that coal would be cut, as the strata gone through in Bore No. 2, Section 20, generally indicates coal to underlie; but, if cut in this trough area, it would probably only underlie a small extent in the centre of the area, as from the slates being traceable on the surface on three sides of the area, and indications of them being seen on the fourth or north side, the coal area would necessarily be limited.

Whareora.—Forming the north and N.E. slopes of Mount Tiger, the same soft sandstones are observed, as in the Awaroa Basin, on the heights, appearing to rest upon slate, while in the hollow area, at base of the Whareora Valley, coal outcrops are obtained on Mr. Whitelaw's property, where it is shewn by a small trial shaft upon the banks of the Whareora Creek.

Shaft, Whareora Creek.

		ft.	in.	
Section No. 23.	Surface	1	0	
	Soft brown sandstone	10	0	
	„ blue and greenish sandstone	2	0	
	Coal (brown)	3	0	
	Shale	1	6	
		16	6	Depth of Shaft.
	Hard white stone with coal pipings	4	6	
	Slate to bed of Creek			

Dip, North.

Further north about 40 chains, near the Whareora Schoolhouse, an outcrop known as Frater's outcrop shows, exposed by a small drive entered in the side of the spur, cutting coal—a probable continuance of the same seam as Section No. 23, and reading as under:—

Frater's Outcrop.

		ft.	in.
Section No. 24.	Surface soil	2	0
	Soft blue to greenish sandstone	3	0
	Coal (brown)	3	6
		8	6

Dip North.

From these outcrops, extending north and N.W. along the valley under the base of the Ngunguru Hills, the coal formation, soft sandstones, appears to hold, being exposed in places on the spur sides until reaching McKinnons' Farm, where recently at the base of a spur the roof of the coal has been struck by a party of gum diggers.

From this point north and west volcanic formation appears to hold, overlying the coal formation in parts, but after crossing a small basaltic plateau till reaching Kamo Valley, the coal formation again appears.

Analysis of Coals from Whareora.

——	1	2	3
Fixed carbon	36·06	51·96	49·80
Hydro-carbon	43·02	35·69	37·66
Water	5·58	7·84	7·76
Ash	15·34	4·51	4·78
Evaporative power ...	4·7	6·7	6·5

Kamo (or Meldrum's) Colliery is a small going colliery and tunnel workings, wrought upon an irregular system, as may be observed from the plan.

The coal here holds about an average thickness of from 8 to 10 feet, with a similar sequence of measuree to those of the Awaroa and Whareora, viz.,

Kamo Measures.

		ft.	in.
Section No. 25	Volcanic Hard white limestone Soft brown sandstone Soft blue to greenish sandstone *Coal* - - - - - - - - - Shale - - - - - - - - -	9 3	0 0
		12	0

Dip, N.E. 8° to 10°.

From the Whareora to this point my observations have been comparatively limited, owing to the quantities of volcanic (basalt) beds which overlie the area in parts, though at the Whareora end the dip of the coal outcrops being north, the measures soft brown sandstone being traced north and west till reaching the volcanic area holding westward toward "Kamo," and here a somewhat similar sequence of measures being obtained, leads me to be of opinion that they are one and the same seam, and a probability exists of the coal holding under the basaltic formation.

Westward from this under base of the range the volcanic formation appears to hold till reaching between Kaurehorehore and Walton's coal outcrops or Whau Whau, a distance of about three miles.

Analyses of Coal from Kamo Mine.

——	1	2	3
Fixed carbon	52·63	49·08	50·01
Hydro-carbon	34·30	37·57	37·67
Water	8·91	9.24	9·61
Ash	4·16	4·11	2·69
Evaporative power ...	6·8	6·3	6·5

Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S., DIRECTOR.

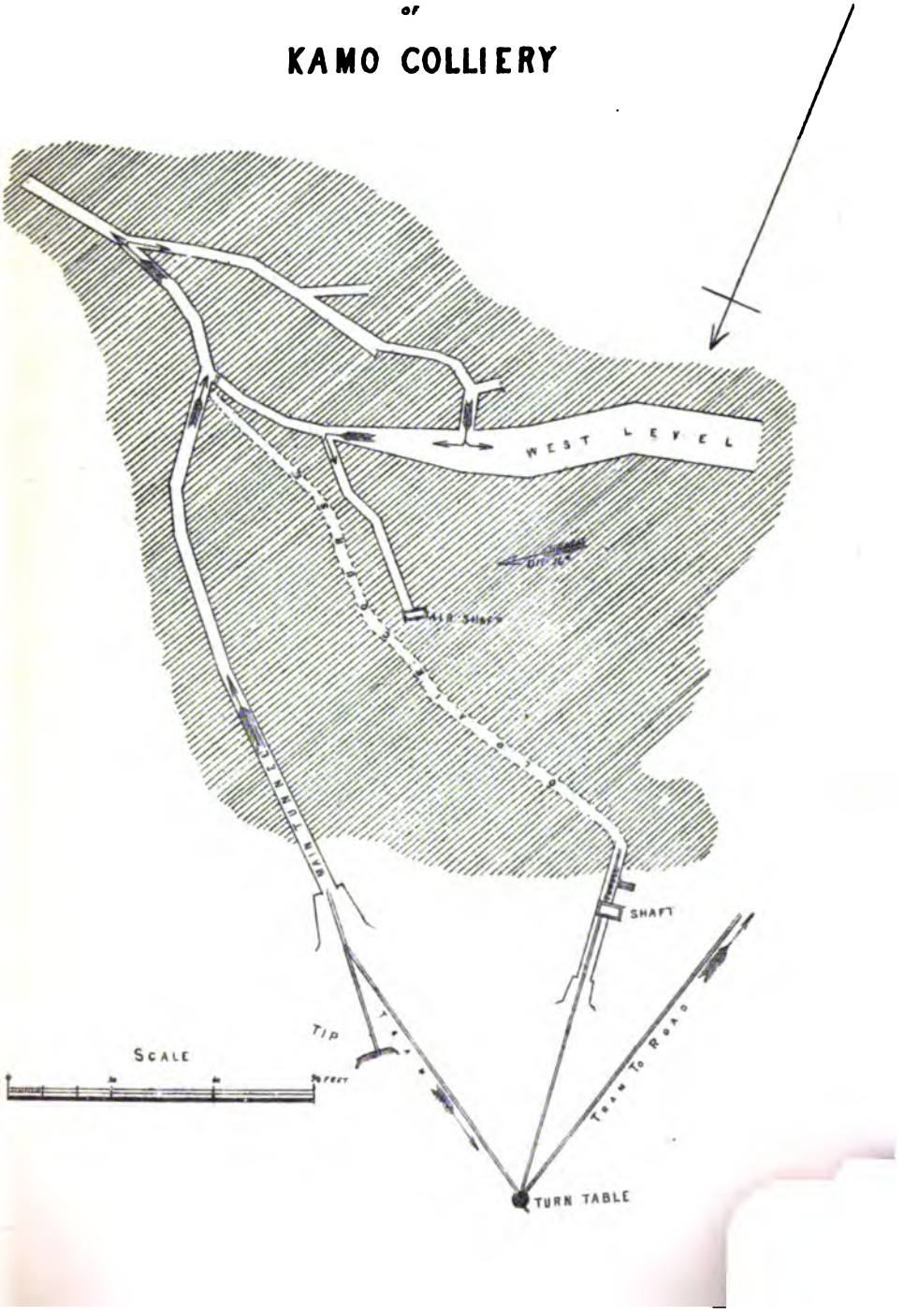
To illustrate Report by R. B. Denniston. May, 1877.

WHANGAREI COAL FIELD

PLAN

OF

KAMO COLLIERY



The *Whauwhau Colliery* is a going colliery formerly wrought by Walton and others as a dip working on an ordinary system of square work, the output then being raised at a costly rate by an engine plane. Subsequently being overcome by water this company had to abandon their works, which since have been taken up by a party of working miners, who after driving a tunnel through a slate bar, cutting coal at 19 chains, have since been enabled to work the mine level free and with profit.

This area on the whole represents that of a basin-shaped area confined by a slate range to the north and N.W., and by a slate bar or ridge to the south and S.E., which to all appearance narrows in on the coal area towards the range in a S.W. direction. On the east side the volcanic formation only is traceable. In this direction nothing definite is known of the extent of the coal area, and will remain a point to be proven by future mining enterprise.

The coal here holds an average thickness in the various working faces of from 6 to 10 feet, and gives a somewhat similar sequence to that of Kamo and Whareora.

Whau Whau Sequence.

		ft.	in.
Section No. 26	Surface		
	Soft green sandstone with fossil shells		
	Coal, brown	8	0
	Shale	2	0
	Hard white stone with coal pipings		
	Slate		

Dip, N. to N.E. 10°.

Here, from the comparison of the various sections and similar characters of the coal, it seems probable that the coal at Whau Whau is the same as that at "Kamo," although it probably exists in a distinct basin-shaped area from the other.

Samples of the various coals found have been forwarded during progress of the work.

North from "Kamo" the surface of the country generally shows to be a volcanic area, holding for a distance of about nine miles till reaching east from Hikurangi.

Analyses of Coals from Whau Whau Colliery (Walton's Mine).

—	1	2
Fixed carbon	47·09	47·91
Hydro-carbon	42·19	40·70
Water	6·99	8·19
Ash	3·73	3·20
Evaporative power	6·1	6·2

Hikurangi.—Round here numerous coal outcrops show exposed on the heights, and the coal may be traced cropping in many of the small creeks, covering a considerable area of country, and holding in thickness varying from two, four, and six feet, showing a general section as follows :—

Hikurangi. ft. in.

Section No. 27 { Soft Brown Grit / Coal - - - - - - - - 4 0 / Shale / Hard grey stone with coal pipings

Dip, N. to N.W.

Continuing down the spur north and N.W. towards and to the swamp country, or nearing the bed of the Wairua River, the coal is again exposed in places till nearing the level of swamp, where, from general indications, it still seems to hold and dip under the swamp area, passing N.W. under and along the base of Hikurangi.

This coal, though brown, shows to be a different seam to that of Kamo and Whau Whau, and appears to be a free burning coal, free from sulphur.

With regard to the quality of this coal, I have been informed by Mr. McInnis, blacksmith at Whangarei, who has used them in his forge, that he found the Whau Whau coal to be not suitable for his purposes. Kamo coal is suitable for light heats ; Hikurangi coal suited well, giving almost as strong and lasting a heat as Grey coal.

In the country holding north between this point and Kawa Kawa I have only hurriedly passed over it, being mainly confined to about the road line which passes through an undulating country, showing mainly slate in the creek beds, and on the heights volcanic measures, which

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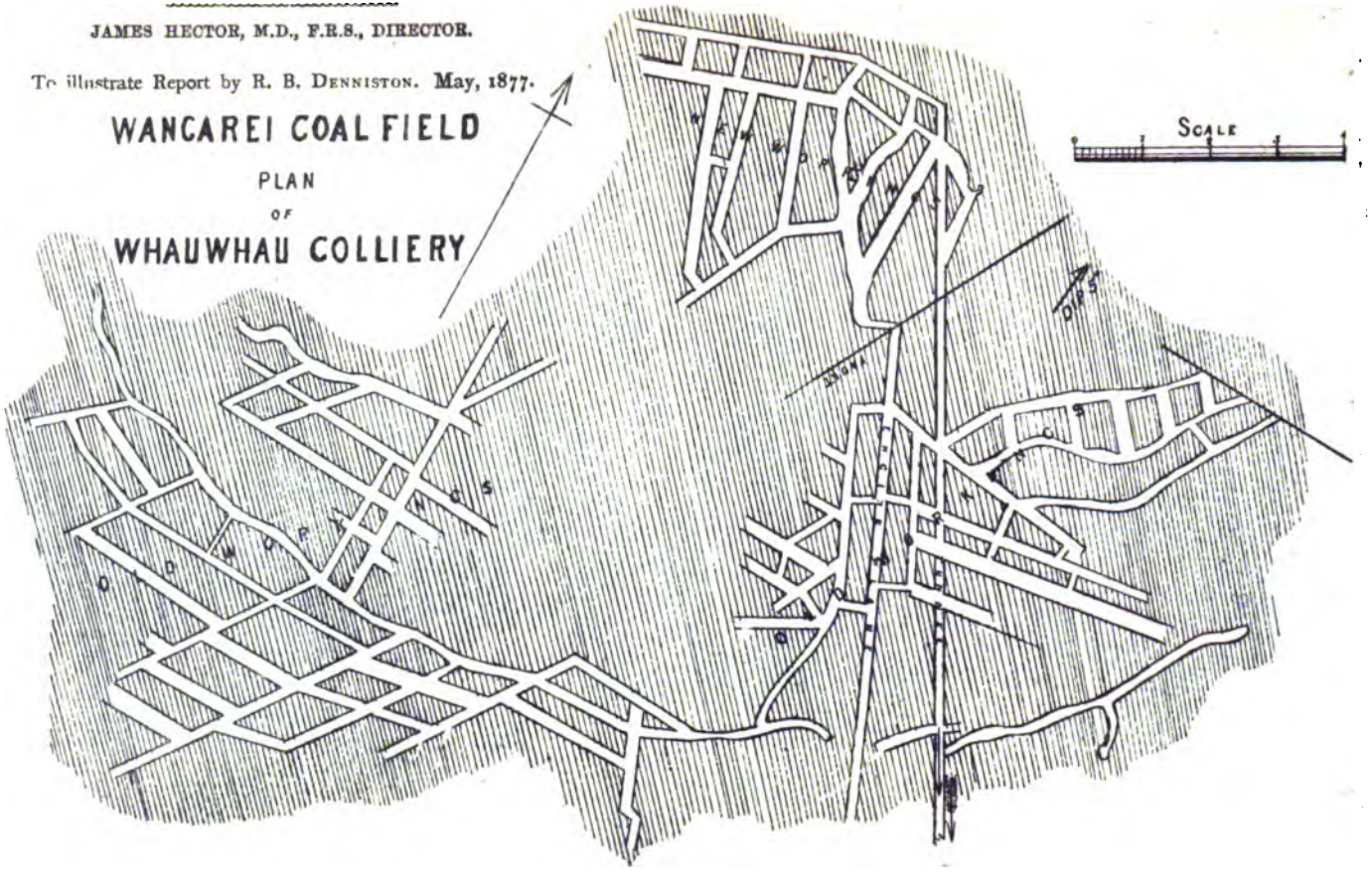
To illustrate Report by R. B. DENNISTON. May, 1877.

WANGAREI COAL FIELD

PLAN

OF

WHAUWHAU COLLIERY



holds covering to Rewa-peka-peka Pa, and from this north an apparent succession of slate ridges are passed until reaching near Kawa Kawa, which here apparently forms a basin-shaped area along a line of low-lying country holding from east to west.

Analysie of Coals from Hikurangi.

——	1	2
Fixed carbon	42·70	44·12
Hydro-carbon	44·46	46·89
Water	5·93	6·39
Ash	6·91	2·60
Evaporative power	5·5	5·7

Kawa Kawa is a going colliery of considerable extent, the coal being wrought by an engine dip, bearing on the coal south from the surface, and the extended working being wrought, as per plan, upon a system of square work, as nearly as the soft nature of the roof will allow.

A section of the measures near the mouth of this drive read as follows :—

Kawa Kawa.

		ft.	in.
Section No. 28.	Soft green sandstone Coal - - - - - - - - - - Shale	8	0

Dip, W. to S.W.,

Showing a somewhat similar sequence to those of Kamo and Whau Whau.

Reaching along the lower level, heading north, which has now been driven to close proximity to the edge of swamp, the coal shows to undulate, varying in thickness from six to ten feet; while, on the opposite level the same undulations are met with, likewise similar variations in thickness till meeting with a fault (on to which this level has been driven), indicating a downthrow south, and generally estimated by those in charge of the works here to be a downthrow of about 70 feet.

In this downthrow area to dip will depend the future permanent workings of this field; and from surface indications, so far as I have

traversed to the south-west from this colliery, about two and a half miles, the measures appear to hold a westerly dip. The work of proving this area will probably be undertaken at no distant date, as the engine dip and lower level are now driven to about water level of present pumping shaft, and the surface water is breaking through a banking in the roof near this level, all but overpowering the present pumping appliances, which will necessitate for the future extension of these workings to dip, the placing of a shaft to dip with heavy pumping appliances, which undertaking, I have been informed by those in connection with the works was pointed out and attention drawn to by Dr. Hector some time ago, or shortly after the commencement of these works.

In places throughout this area bores have been placed to the dip of the present works, which I give as supplied to me by Mr Williams, the present manager of the mine.

Kawa Kawa Bore No. 1.

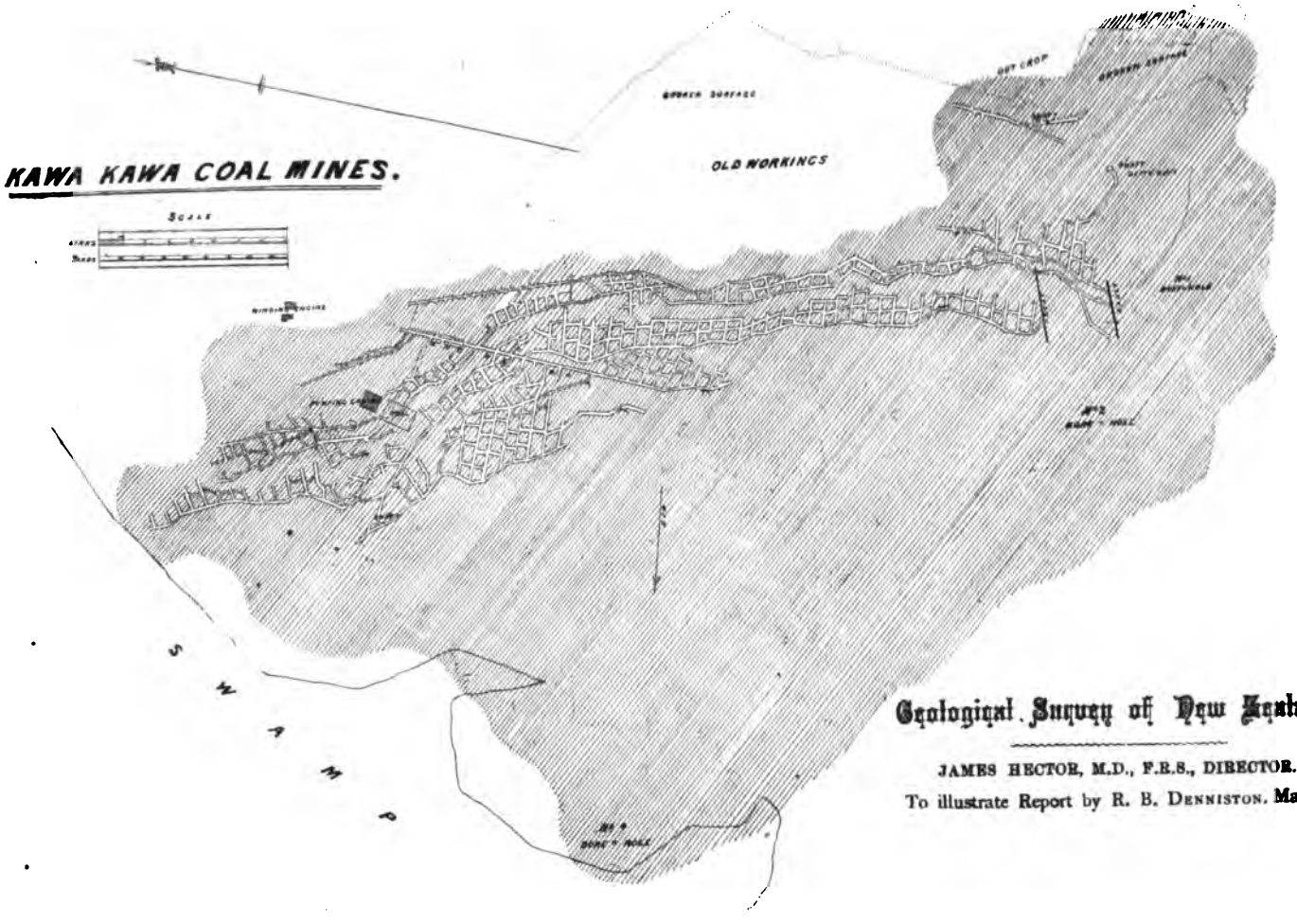
Section No. 29.

	Thickness. ft.	Thickness. in.	Total Thickness. ft.	Total Thickness. in.
Soft clay	20	0		
Soft sandstone or clay stone	25	0	45	0
Hard rock	51	6	96	6
Soft white stone	15	0	111	6
Soft green sandstone	14	0	125	6
Hard and soft green sandstone boulders and clay	14	0	139	6
Hard grey limestone	14	0	156	6
Conglomerate	10	0	166	6
Coal	4	6	171	0
Fire-clay	2	6	174	0

Kawa Kawa Bore No. 2.

Section No. 30.

Hard cement	6	8		
Mixed brown clay and pebbles	17	1	23	9
White pipe-clay and pebbles	28	3	52	0
Stiff green clay much oxidized	20	0	72	0
Hard brown clay	2	0	74	0
Hard grey limestone	11	3½	85	3½
Hard grey and greenish-coloured clay	3	9¾	89	1¼
Hard grey limestone	4	10¾	94	0
Grey and brown limestone	11	3¼	105	3¼



Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S., DIRECTOR.

To illustrate Report by R. B. DENNISTON. May, 1877.

		Thickness.		Total Thickness.	
		ft.	in.	ft.	in.
Section No. 30 *(continued.)*	Hard grey limestone slightly mixed with clay	7	0¼	131	3¾
	Hard brown sandy clay	1	10	133	1¾
	Free cutting reddish to brown limestone mixed with clay	3	6½	136	8¼
	Hard brown clay	1	7	138	3¼

Kawa Kawa Bore No. 3.

Section No. 31.—No record kept.

Kawa Kawa Bore No. 4.

		Thickness.		Total Thickness.	
		ft.	in.	ft.	in.
Section No. 32.	Strong yellow stone	30	0		
	Brown sandstone		6		
	Compact mass of chert imbedded in strong clay	13	4		
	Black marl		6		
	Stone, very hard	1	0		
	Drift gravel (loose)	6	3		
	Brown soft sandstone	3	0		
	Stone, very hard	1	8		
	Grey sandstone	8	6	64	9
	Blue limestone, hard and fine grained	17	7		
	Band of blue clay		4		
	Blue limestone, very hard	15	8		
	Blue clay parting		3		
	Blue and grey limestone	55	6		
	Clay parting		4		
	Grey limestone	11	0		
	Clay parting		3		
	Grey limestone	6	0		
	Clay parting		3		
	Grey limestone	20	6		
	Clay parting	1	6		
	Grey limestone	34	6	225	6
	Coal, inferior, mixed with black clay coal and marl	3	4		
	Fire-clay	14	0		
	Brown shale		11		
	Blue stone, with a trace of lime	4	5		

		Thickness.		Total Thickness.	
		ft.	in.	ft.	in.
Section No. 32 *(continued.)*	Fire-clay	2	4		
	White sandstone, hard and fine grained	3	8		
	Sandstone, coarse	3	1		
	„ dark	11	0	268	0
	Blue stone, with bands of brown shale	30	0	298	0
	Coal, inferior (brown)		3		
	Brown shale		9		
	Blue stone, with bands of blue shale	18	0	317	0
	Coal, good		3		
	Brown stone fire-clay, mixed with coal		9		
	Blue coarse stone	16	0	334	0
	Blue sandstone, fine grained, hard and compact	34	0	368	0
	Grey sandstone	7	0	375	0
	Blue stone, free cutting	17	0	392	0
	Blue stone	13	0	405	0
	Blue stone	30	0	438	0

From the positions of these bores, as may be seen from plan, Bore No. 1 and 2 should, if the readings and description of the measures cut have been carefully taken during the progress of the work, give a somewhat reliable sequence of the measures overlying the coal to dip and the downthrow area or underlay of fault.

That of Bore No. 4, on the north side of the area, I should be of opinion has bottomed on slate, pricking the coal at 317 feet.

The probability is that the further extension of any of these north levels under the swamp would interfere with the safety of this mine, and a probability also exists that the coal in this further northern course would thin as in Bore No. 4., and would probably not hold a great distance before being met with the rising slopes of the slate ridge forming the northern confines of this area.

REPORT ON COMPARATIVE VALUE OF COALS.

BY W. LAIRD, ENGINEER TO S.S. ARGYLE.

Auckland, 31st July, 1877.

For your information I herewith furnish a report, showing the result of a trial of one ton of coal from each of the following mines—Kamo and Whau Whau, both of Wangarei, and the Bay of Islands:—

PARTICULARS OF TRIALS.

Date—1877.	Name of Coal.	Length of Trial.	Distance Run.	Quantity of Ashes by Measures.	Weather.
April 27	Kamo ..	4 hours	33¼ miles	10 per ct.	Very light fair wind; sea quite smooth; no sail set
April 28	Bay of Islands	4 hours	33¼ ,,	12 ,,	Very light head wind; no sea.
April 30	Whau Whau	3 hours	24 ,,	12½ ,,	Light fair wind; sea quite smooth; all fore and aft sail set.

Remarks.—Average number of revolutions per minute, 132; pressure of steam, 70 lbs.; vacuum, 23¾ inches. The distance run during each trial was measured by the patent log. During the first and second trials there was not the least difficulty in keeping up steam, but on the third trial to keep up the speed of the engines and pressure of steam to the mark, the blast had to be opened. In each case the ashes were carefully measured (not weighed). Steam was got up with Whau Whau coal, and 4½ miles run before the trials commenced. The number of revolutions, pressure of steam, height of vacuum, and height of water in the boiler was kept as near as possible the same in each case.

THE OTAGO COAL FIELDS.

[MEMORANDUM FOR MR. KNOWLES.]

Wellington, July 25, 1877.

With reference to the authority contained in your letter of 29th May last, the enclosed Report, by Mr. Denniston, on the Green Island coal-field is forwarded.

I beg to call attention to Mr. Denniston's remark on page 1,—that these mines have been hitherto carried on without any working plans, a course which cannot fail to involve great danger to the miners, and waste of coal in future operations.

Mr. Denniston has also drawn my attention to the circumstance that his survey of Sampson's Colliery shows that the railway crosses an area of partially worked ground, and that difficulties may arise in consequence, from the sinking of the railway line.

I have retained the plans, and would suggest that the Report be returned to me for the purpose of being printed with others now going through the press.

I also enclose a memorandum and plan of the Kaitangata Mine, which I visited on 12th April last.

JAMES HECTOR.

KAITANGATA COAL MINE.

[MEMORANDUM BY DR. HECTOR.]

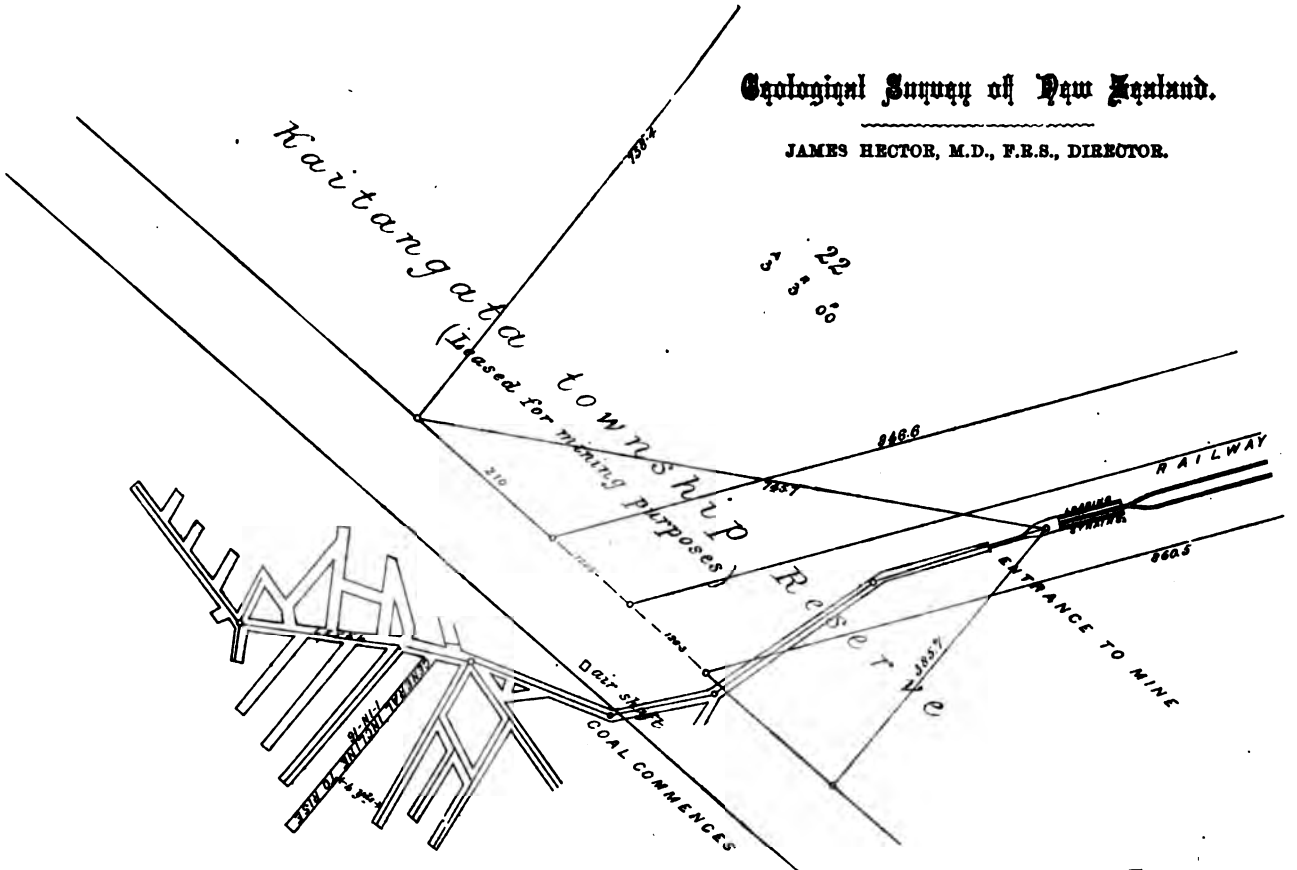
This mine is opened on the same coal seam which appears on the coast at Coal Point, and which was worked as early as 1858.

The coal formation extends from this point northwards, over an area of 45 square miles, with seams varying from 6 feet to 30 feet in thickness, and the total quantity of coal available was in a former Report estimated at 100,000,000 tons. ("Coal Deposits of New Zealand," Hector, 1866, p. 10.)

The coal was formerly worked under great disadvantages, at a point close to the sea beach, and difficult of access, but the seam has now been traced to the inland side of the coast range of hills, and the present mine is opened in a situation convenient for transporting the coal by railway to Dunedin.

For the purpose of connecting with the main line of railway, a branch line has been constructed by the Coal Company, at a cost of £13,000.

The form of the ground has greatly favoured the opening of this mine, as a gully cuts back into the hill, and penetrates the heavy cover of conglomerates, which overlie the coal seam.



Kaitangata Raily. and Coal Company's Lease.

From the head of this gully a tunnel has been driven—70 yards in length—through the roof of the coal, which here consists of a coarse conglomerate of rounded pebbles, strongly cemented together; the drive then turns more towards the direction of the strike, as it enters the coal in such a manner as to cut on a level course through its entire thickness of 27 feet in 110 yards. From this level headings have been driven, both to the rise and also to the dip.

The seam is of fair quality, and the coal is hard, especially in its lower parts, where it becomes of a bluish-black color, and has the joints enfilmed with Pyrites (brass of the miners), and in parts approaches in external appearance a semi-bituminous coal, similar to that found at Pakawau, Nelson.

In this part of the seam the coal is also distinctly laminated with alternating thin layers of jet and dull coal, in a similar manner to the coal of New South Wales.

The mine is intended to be worked by "posts and stalls," each about 16 feet square. The coal has back joints, but no cutters.

The seam dips 7° W.N.W., and entirely corresponds with the Coal Point seam, which has an easterly dip, so that the formation must form a flat anticline, extending northward in the direction of Mount Misery; the Edendale and Lovel Creek coal being on the western side, while the Tokomairiro coal belongs to the east side of the arch.

At the time of my visit (April 24, 1877) 17 miners were employed, each excavating about three tons per day, at the rate of 3s. 6d. per ton. The haulage to shoot outside the mine costs threepence extra; the freight to Dunedin is stated to be eight shillings; and the royalty one shilling per ton. But to this must be added the interest on the capital sunk by the company, which, I understand, is £25,000, inclusive of the cost of the branch railway.

The prospects of the mine are favorable, as a good quantity of coal can be worked to the rise, owing to the steepness of the hill; and in that district the quality of the coal may be expected to improve, especially if the conglomerate roof holds throughout, but the chief extension of the mine, which, in the company's ground, will no doubt be to the dip of the coal, will be mined by shafts sunk within the boundary of the Kaitangata township, over which this lease extends.

The following table gives the analysis of samples of coal from various parts of the seam as at present worked :—

——	1	2	3	4	5
Fixed carbon	43·02	44·08	44·13	44·72	44·89
Hydro-carbon	40·27	38·17	38·32	37·15	37·29
Water	14·49	15.42	15·44	15·62	16·13
Ash	2·22	2·33	2·11	2·51	1·69
Evaporative power ...	5·59	5·72	5·74	5·80	5.82

REPORT ON GREEN ISLAND COLLIERIES, OTAGO.

BY R. B. DENNISTON, COAL VIEWER.

15th July, 1877.

During the past few weeks, as instructed, I have visited the various working collieries in and around the Green Island district, viz., Otago, Freeman's, Samson's, Walton Park, and Saddle Hill Collieries, in order to report on the present state of the workings, obtain copies of working plans, and likewise any statistics that may be of service to the Department.

These collieries I unexpectedly found carrying on somewhat extensive workings without the aid of any plans, and therefore had to undertake a survey of the various winnings, plans of which accompany this report, showing workings as they stood at dates of my survey. These plans show areas traversed, areas partially wrought through at date of survey closed up, areas partially wrought and settled down. The stoppings, trap doors and screens are also shown, the direction of the currents of down and up cast air being indicated by arrows.

Otago Colliery.—This mine, which is situated about a mile to the N.W. of Green Island Railway Station, is a going colliery of three years' standing. It is wrought by a square shaft, sunk through soft strata to a depth of 140 feet to a seam of coal (lignite) 16 feet thick, dip E. 10°N., 1 in 10. I found that no record had been kept of the measures passed throught in sinking the shaft.

From the soft nature of the overlying strata and likewise of the floor it has here been thought judicious to win from six to seven feet only from the centre of the seam, leaving a thickness of coal overhead and underfoot for the safety of the workings.

The coal here is wrought upon an irregular system, which may be said to border upon the Scotch system of "Room and Rance."

The main level to the north had on date of the survey been driven along the strike of the coal for 708 links, with a width of about 13 feet. This level shows the coal to undulate, thinning down in places to four

or five feet. The main north heading is driven 191 links, with a width of nine feet, and the south heading 515 links by six feet wide, rooms breaking off at intervals right and left from each of these, and which are driven 14 feet wide.

The intervening space between these headings is a partially wrought area, which at the time of the survey was closed, with the exception of the air course, which passes through the centre of the area.

The total output from this mine I have been unable to obtain, as Mr. Usher, the party in charge of the accounts of the collery, declined the labour of making it up.

The cost of winning the coal, as supplied to me there, is as follows, delivered at the pit head :—

Large coal	- - - - -	4/6 per ton
Small „	- - - - -	3/10 „ „
Slack „	- - - - -	1/ „ „

Subject where levels are being driven to an additional price on above of 5s. per yard.

The mine gives employment to nine miners, who win upon an average from two to two and a half tons per man per day.

The workings generally, so far as I have been able to traverse them, may be said to be in fairly workable order, with the exception that the return air course I found upon traversing to be in a disgraceful state—in many places almost choked to the roof with fallen debris, and necessarily weakening the air. Upon questioning the miners I received great complaints against the proprietors, who I am informed are usually negligent with regard to the air courses and general repairs of the colliery.

Freeman's Colliery, which is situated from 20 to 25 chains to the west (rise) of the of the Otago Colliery, is a crop workings of 18 months' standing.

The coal (lignite) is 16 feet thick, with a dip E. 10° N. of 1 in 10, it being the same seam as that wrought by the Otago Colliery. It is wrought by a dip drive entered in the coal from the hill side, and to date of survey driven a distance of 347 links 6 feet wide, being opened to the right and left as a "Room and Rance" working, the rooms being

Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S., DIRECTOR.

To illustrate Report by R. B. DENNISTON. July, 1877.

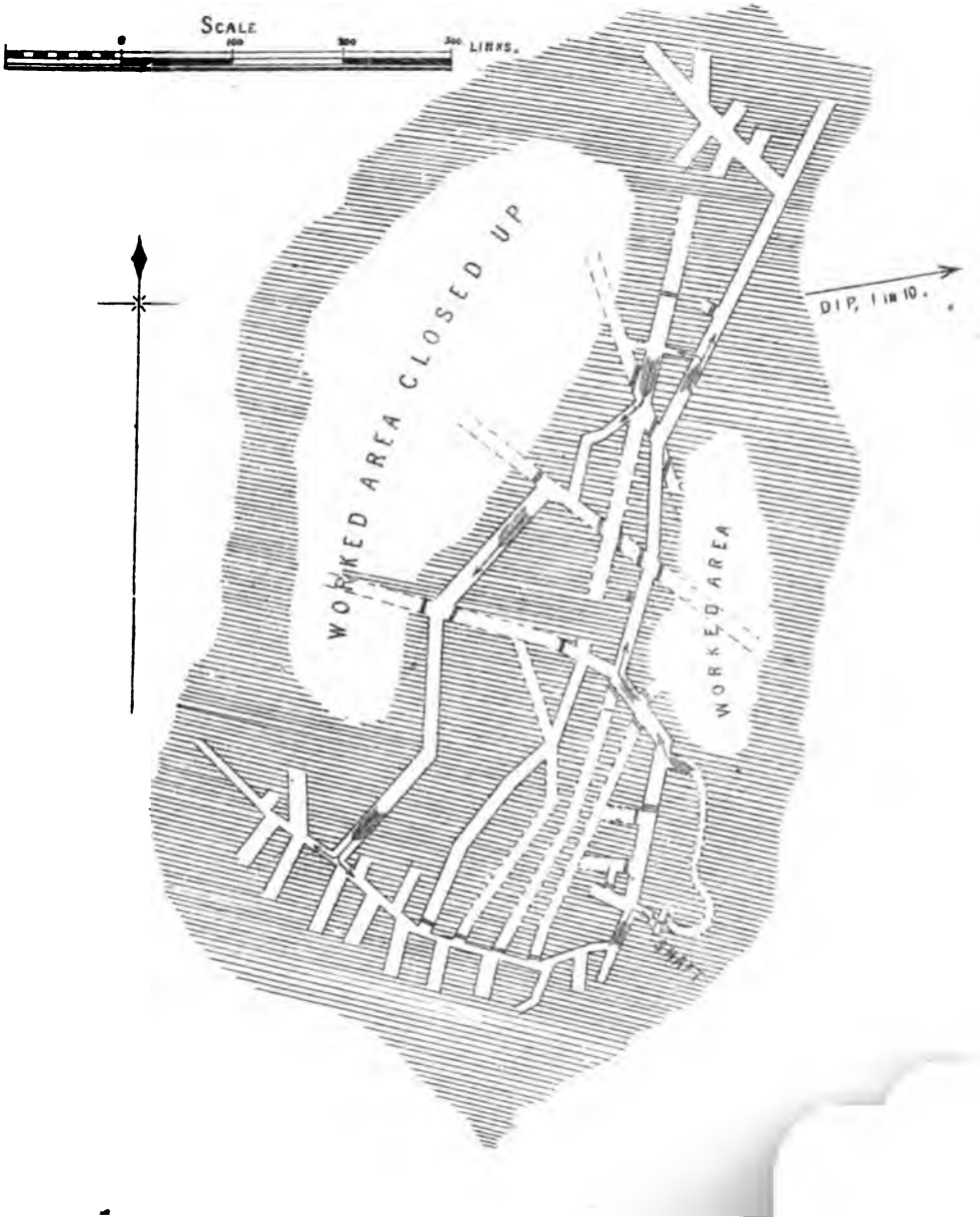
OTACO COAL FIELDS

PLAN

OF

OTACO COLLIERY

CREEN ISLAND.



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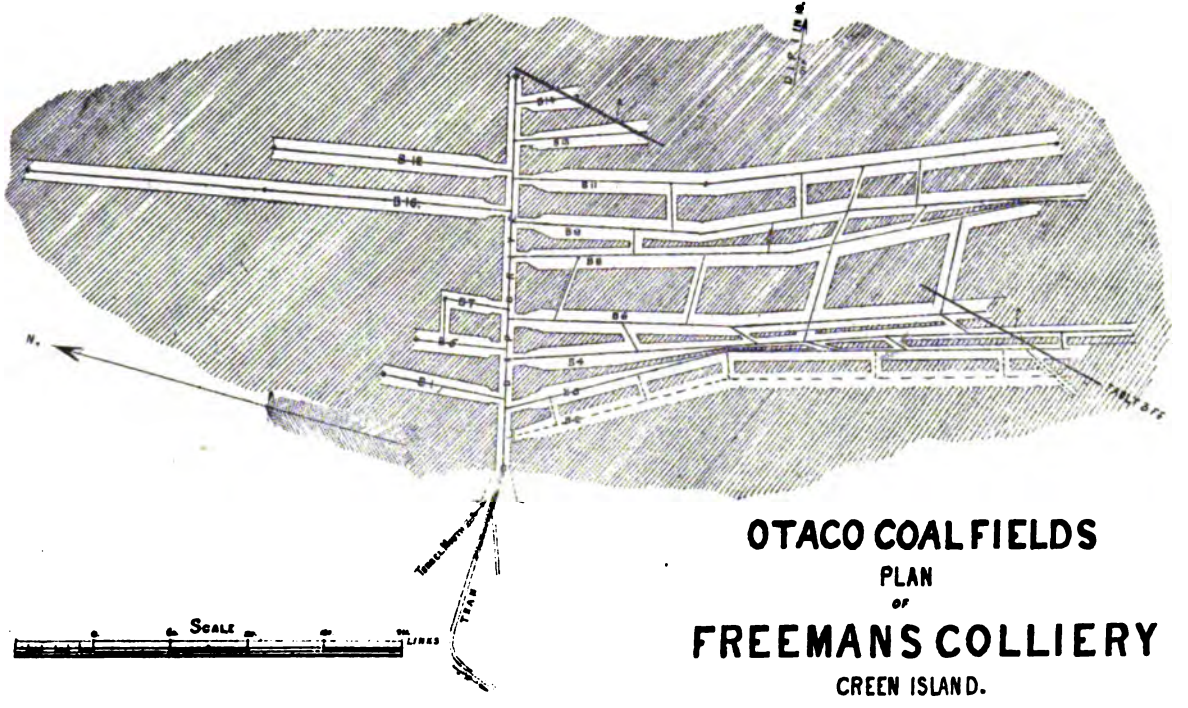


OTACO COAL FIELDS

PLAN

OF

FREEMANS COLLIERY

CREEN ISLAND.

driven from 14 to 18 feet wide, while here as in the former colliery from 5 to 6 feet, or centre only of the coal is won.

This mine at present gives employment to 13 miners, who win upon an average from two to two and a half tons per man per day.

The costs of hewing the coal here are somewhat similar to that of the Otago Colliery, viz.:—

Large coal	- - - - -	4/6 per ton
Small „	- - - - -	3/6 „ „
Slack „	- - - - -	o/o „ „

The total output, as supplied by the proprietors, to date is 5515 tons, and the workings as they now stand show about two acres wrought, which will give an equivalent of 459 tons of coal won per acre per foot thick.

The workings here are at present standing well, but when extensions proceeds and the weight from the roof begins to be felt great waste may be looked for, in loosing what pillars now stand, as the soft nature of the roof, loose drift sands, and floor, sandy shales, does not warrant for the safety of the mine, the rooms being driven more than 12 feet wide, while here they are wrought 14 feet and in places 18 feet wide, with in most instances a comparatively slight thickness of wall or rance between each room.

Although the general opinion here is that this is a different seam to that wrought by the Otago Colliery, probably in consequence of the great difference in depth at so short a distance, my opinion is that they are the same seam probably faulted down about 30 or 40 feet eastward to the Otago Colliery area, indications of which I observed on a spur passing in a line N.N.E. S.S.W. between the two collieries. This will doubtless be proven in time upon both workings nearing their boundary.

A small minor fault has been cut and followed in places which may be observed marked in plan, with a downthrow eastward of three feet, and this would most likely be followed by larger ones in this bearing as the coal measures apparently basin eastward.

Samson's Colliery is situated S.E. from Freeman's Colliery about 80 chains, and is convenient to the Dunedin and Balclutha Railway. It is worked by a shaft sunk through soft strata on to the coal, the sequence of which I give as taken from records kept by Mr. Samson:—

Sequence of Samson's Shaft.

			ft.	in.
Surface				
Plastic clays	- - - - - -		10	0
Quartz sand	- - - - - -		48	0
Fire-clay	- - - - - - -		4	0
Coal (lignite)	- - - - - - -		1	6
Micaceous fire-clay	- - - - -	4 0		
White sand	- - - - -	4 0	8	0
Coal (lignite)	- - - - - -		2	0
Micaceous fire-clay	- - - - -		2	0
Brownish „	- - - - -		3	0
Coal (lignite)	- - - - - -		4	0
Micaceous fire-clay, white	- - - -		5	0
„ „ brown	- - - -		4	0
Coal (lignite)	- - - - - -		6	0
Fire-clay	- - - - - -	2 0		
Bluish sandy clay	- - - -	6 0	8	0
Loose running sand	- - - - -		12	0
Micaceous clay	- - - - - -		4	0
Soft grey sandstone	- - - - -		4	0
Coal (lignite)	- - - - - -		18	0
Shale				
			144	6

Dip, E. 10° N., 1 in 10.

The coal here bottomed on would appear to be the same seam as that worked at Freeman's and the Otago Colleries, as, when there, I was informed that several thin seams of coal overlie the present workings of these mines.

The coal here is wrought upon the Room and Rance system, the workings generally being very regular throughout the area traversed, while the same regularity appears to hold in the area closed up and settled down, as far as could be seen in parts which I traversed.

The roadways, &c., at this mine are driven as nearly as possible of the width shown in the accompanying table:—

Headings	6 feet
Levels	9 „
Rooms	14 „

While six feet only at the centre of the seam is wrought, for reasons formerly mentioned in connection with the Otago and Freeman's Colleries.

The mine gives employment to 18 miners, who are estimated to

Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S., DIRECTOR.

To illustrate Report by R. B. DENNISTON. June 23, 1877.

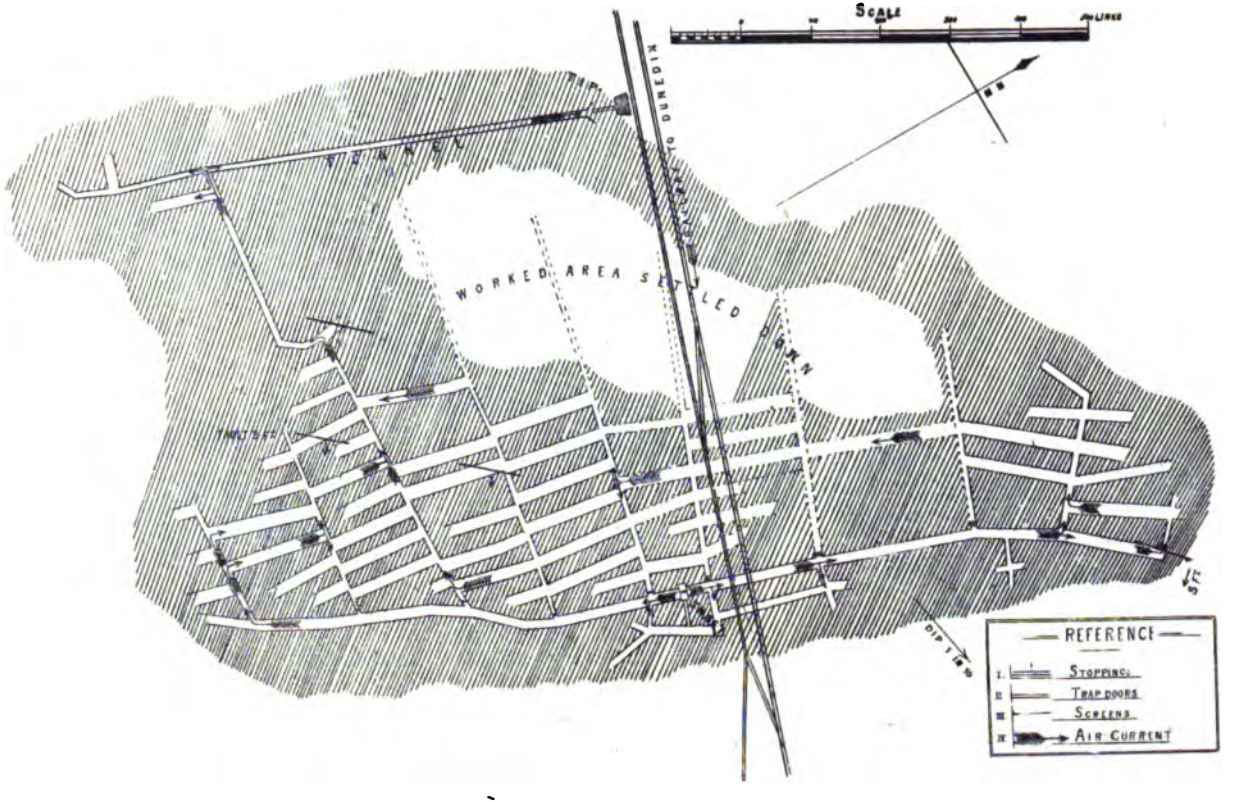
OTACO COAL FIELDS

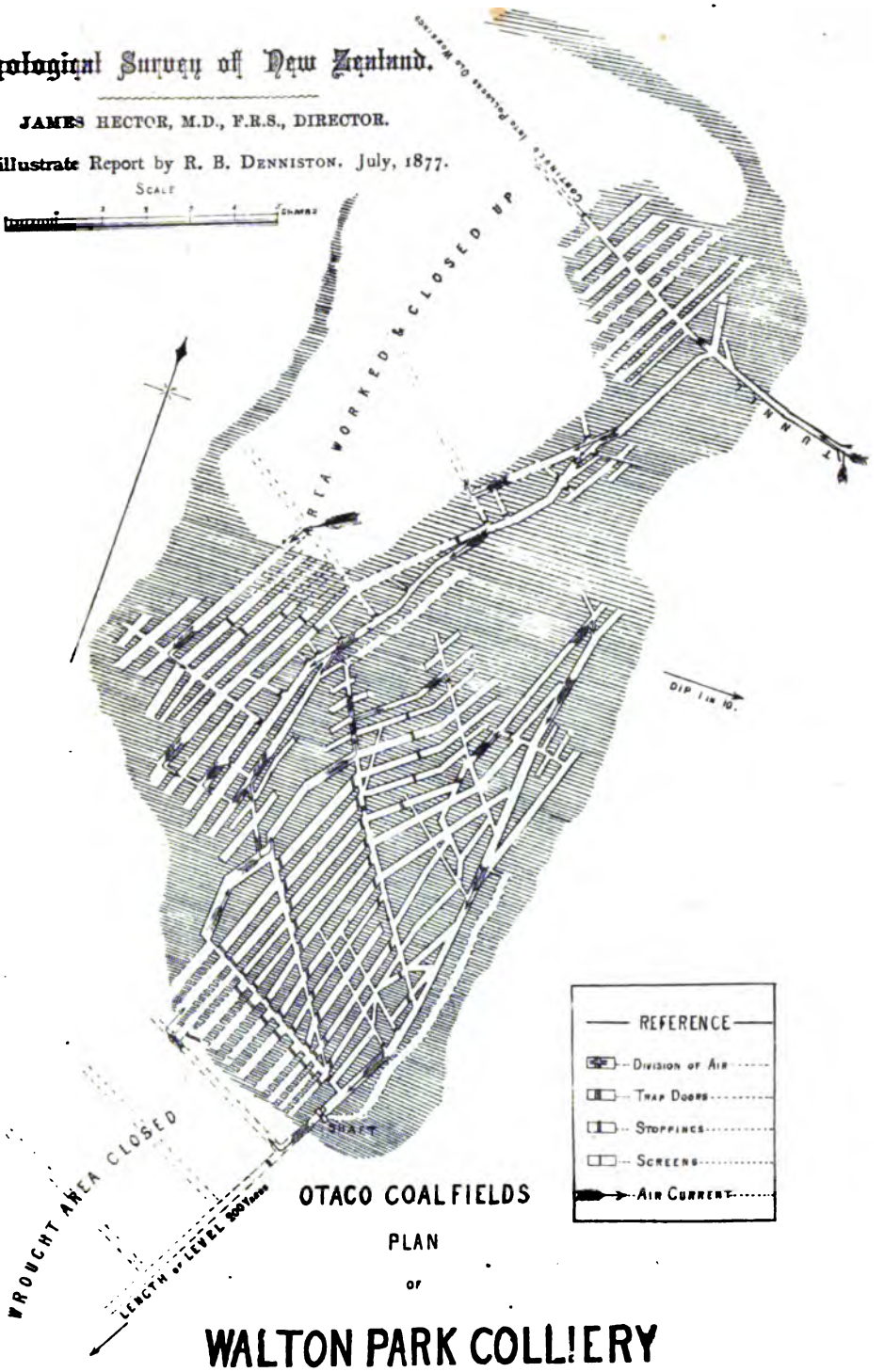
PLAN

OF

SAMSONS COAL MINE

GREEN ISLAND




Geological Survey of New Zealand.
JAMES HECTOR, M.D., F.R.S., DIRECTOR.
To illustrate Report by R. B. DENNISTON. July, 1877.
SCALE
CHAINS
AREA WORKED & CLOSED UP
TUNNEL
DIP 1 in 10.
SHAFT
WROUGHT AREA CLOSED
LENGTH OF LEVEL 300 Yards
REFERENCE
DIVISION OF AIR
TRAP DOORS
STOPPINGS
SCREENS
AIR CURRENT
OTAGO COAL FIELDS
PLAN
OF
WALTON PARK COLLIERY
GREEN ISLAND

hew on an average from two to two and a half tons per man per day.

The prices paid here for hewing, including trucking to the bottom of the shaft, are—

Large coal	4/6 per ton
Small coal	3/10 „ „
Slack	1/ „ „

Subject to an additional 5s. per yard extra where levels are being driven.

The total output for the time the mine has been working, viz., three years, approximately estimated, is about 27,000 tons.

The underground workings here I found to be in thoroughly satisfactory order, due attention being paid in driving the levels, headings, and rooms or boards, to keep the work as straight as possible, while the roadways in all instances are kept in thorough good working order.

No exact extent of the acreage wrought can be given, as only part of the area has been traversed, the remaining portion being closed up, and in parts settled down.

Due attention is here paid to the ventilation of the mine, the downcast air being taken by the shaft, and hence along the levels; the up-cast air spreading through the workings to rise, and being ultimately discharged along a tunnel about seven chains west from the shaft.

As may be observed from the plan a moderately efficient, though somewhat incomplete system has been adopted for dividing the air, the two up-casts starting from a point near the straight run of the tunnel. This system gives an increased velocity to the up-cast air, and at the time of my visit was working admirably, and to the complete satisfaction of the underground manager, Mr. W. Samson.

It will also be observed from the plan that the railway crosses an area of partially wrought ground, which may eventually cause some difficulty when that area is allowed to settle down.

Walton Park Colliery.—About one and a half miles S.E. of Samson's Colliery, situated at Fairfield, the N.E. base of Saddle Hill, the Walton Park Colliery is being worked by a tunnel at the north side of area, and by shaft at south end. The shaft, which is 174 feet deep, has been sunk through soft strata, of which no record can be obtained; but I gathered from outside information that it passed through four or

five seams of lignite, the lowest of these seams being the one at present wrought. This seam, which is 18 feet thick, dip E. 10° N., 1 in 10, is probably the same seam as that worked in Samson's, Freeman's and the Otago Collieries.

The coal here is wrought upon a regular system of Room and Rance, the roadways, &c., being driven as follows :—

Headings	6 feet
Levels	12 to 14 „
Rooms or Boards	14 „

While here my attention was drawn to the system of driving the headings in a V form, with the object of easing the trucking of the mineral to the shaft bottom, which work is generally done by the miners at this colliery, being included in the price paid for hewing.

Four to six feet only from the centre of the coal is likewise taken out in this mine for reasons formerly mentioned in connection with the other collieries.

The total out-put obtained from the mine is approximately estimated at about 71,911 tons.

The acreage wrought from the area cannot be obtained, owing to the greater part of the old workings, known as Lowden's and Pollock's, being inaccessible.

The average quantity of coal won per man per day is about two to two and a half tons, the cost of hewing being as follows :—

Large coal	4s. 6d. per ton
Small „	3s. 10d. „
Slack „	1s. 9d. „

Subject to an additional price of 5s. per yard when levels are being driven.

The workings, so far as traversed, may be said to be in satisfactory order, due attention being paid to the roadways, which I found to be in a thoroughly good condition.

The air, I found, worked satisfactorily, the down-cast air being led into the workings in two divisions, the up-cast air being discharged along the main level, and thence up the shaft, as shown on the plan.

The fact that these extensive workings having been carried on without the assistance of any working plan, reflects somewhat upon the

Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S., DIRECTOR.

To illustrate Report by R. B. DENNISTON. July, 1877.

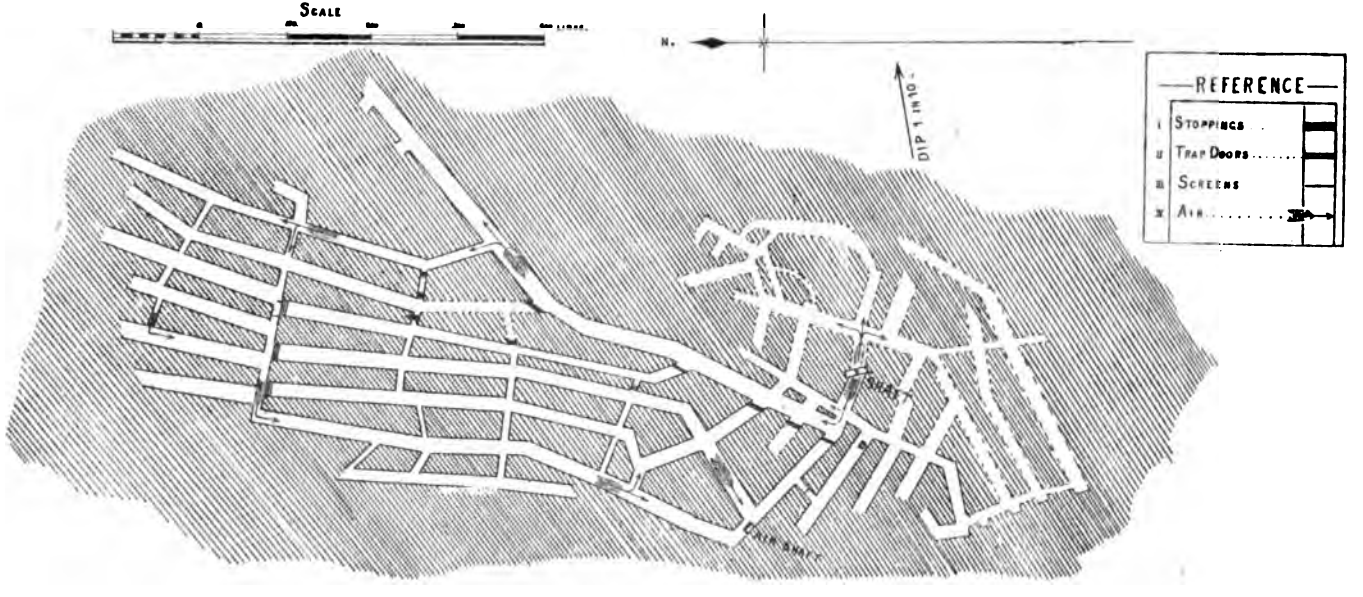
OTACO COAL FIELDS

PLAN

OF

SADDLE HILL COLLIERY

CREEN ISLAND



company, but under the circumstances throws great credit on the underground manager, Mr. Lindsay, who, under great difficulties, has managed to extend the workings in so regular a manner.

About 20 to 25 chains west of the up-cast shaft a bar of slate is seen passing from north to south, generally indicating an upthrow fault up to the west. This, judging from the general bearings, is probably a continuance of the same fault mentioned as occurring between the Otago and Freeman's Collieries; and yet further to the west, a partially denuded area is seen, schists appearing in the low ground on the line of the Chain Hill formation, capped on the heights by the coal measures which hold up to the N.E. slopes of Saddle Hill, where they pass under basalt.

At a distance of about two miles west from Walton Park is situated the

Saddle Hill Colliery.—A going colliery, wrought by a shaft 75 feet deep, sunk through soft strata, of which no complete record has been kept at the mine, but which reads as supplied to me by the proprietors, Messrs. Christie, Bros :—

Shaft, Saddle Hill Colliery.

	ft.	in.
Surface White quartz sand „ drift „ Micaceous fire-clay *Coal* (lignite) - - - - - - - -	2	0
White sand *Coal* (lignite) - - - - - - - -	4	0
White sand *Coal* (lignite) - - - - - - - -	7	0
White sand Micaceous fire-clay and soft blue sandstone *Coal* (lignite) - - - - - - - -	18	0
Shale		

Dip, east, 1 in 10.

The sequence being somewhat similar to that of Samson's, Freeman's, Otago and Walton Park Collieries, and probably here the same seam of coal is being wrought.

In these workings a small shaft has been sunk to a depth of 80 feet, with a view of ascertaining the existence of any lower seams, the following strata being passed through :—

Shaft in Saddle Hill Colliery Workings.

	ft.	in.
Shale		
Coal	1	0
Micaceous fire-clay		
Reddish soft sandstone		
White „ „		
Reddish „ „		
Slate		
In all	80	0

On the whole giving a sequence of the measures, from surface to the slates, of 154 feet.

The coal here is wrought upon a somewhat regular system of Room and Rance; the rooms, which are here driven 14 feet wide, being made also to serve the place of headings, being driven at an angle to the strike of the coal, by which means an easy gradient is obtained for trucking the coal to the level.

Since the commencement of the colliery, about two years ago, about 14,000 tons of coal have been won, the prices for trucking, &c., being about the same as at the other district collieries, though here, as at Freeman's, the cost of small coal is somewhat less than at the other collieries.

Large coal	4s. 6d. per ton.
Small „	3s. 6d. „
Slack „	os. od. „

Subject to 5s. per yard additional where levels are being driven.

The coal won is from two to two and a half tons per man per day.

The workings here, so far as I have been able to traverse them, are in good order, that is the workings west from the shaft; those to the east I have not traversed, as they were closed up. I have, however, sketched these workings in the plan from data supplied to me by the manager, Mr. McLauchlan.

The ventilation of the mine works well, the down-cast air being led down the present working shaft, thence along the main level, being spread through the workings and conducted to a small shaft placed for the up-cast air.

About six feet or centre of this coal only is wrought.

The workings here, as they at present stand, show that about five

acres of coal has been wrought, with a net out-put of 14,000 tons, which would give approximately 456 tons per acre per foot thick.

REMARKS.

The present coal workings are placed near the S.W. and western side of a basin-shaped area, where the coal measures occur near the surface, and necessarily give somewhat shallow workings.

The field appears to be bounded by a slate ridge, passing from Saddle Hill, south and north, crossing Chain Hills, where it is overlaid in parts where preserved from denudation by coal measures which probably hold in the direction of Flagstaff Hill. Eastward from this the coal appears to hold under the Kaikorai River and Valley in the direction of, and as far as, Caversham, where the measures are all but horizontal, the coal in all probability lying at a considerable depth below the surface.

Approximately about eight square miles of coal may be looked for in this district.

From data given in the body of this report it will be seen that in the case of the Saddle Hill Colliery a yield of 456 tons per acre per foot thick has been obtained up to the present time, and when the stoops or rances are drawn this would probably be doubled.

With this return of 912 tons per acre per foot thick, a total tonnage may be looked for from this district of 28,016,640 tons, if the present system of working six feet only from the centre of the seam be followed; or 74,711,040 tons if the whole thickness of the seam be worked.

The above tonnage would be subject to deduction for coal already won, if it be desired to estimate the quantity which yet remains to be worked.

The system of work, Room and Rance, which is generally adopted in the various workings here, is, considering the soft nature of the roof and floor, on the whole the safest system which could be adopted, as each Rance gives considerable strength and support to the mouth of the opposite Room. An additional strength is caused by working six feet only from the centre of the seam, which, although appearing a waste at

first sight, is practically the best means of giving a safe and lasting working.

Other modes of working may be adopted, which, at the outset, might get a greater proportionate tonnage from the seam, but this would ultimately necessitate extensive timbering, &c., an expense here which, when placed against the additional tonnage that would be obtained, would probably render any such system more costly than the present mode of working out the centre of the seam.

In all instances the slack has to be raised to the surface, as experience proves that when left underground it ignites. No demand exists for it at present, and necessarily it is thrown to waste. Roughly speaking, I should estimate the amount of slack as equivalent to about one third of the coal won.

In one instance, at the Walton Park Colliery, I have seen the slack utilised to a small extent in the manufacture of bricks, it being mixed with clay to assist in burning the brick. The slack when burnt out does not reduce the size of the brick; less clay is used, and the cost and quantity of fuel is also reduced below what is used in the ordinary mode of manufacture.

In four instances, out of the five collieries at present at work, the coal is wrought by shafts, varying in depths as given in the body of this report; the remaining one (Freeman's) is wrought by a "Dip Drive," entered in the face of the coal.

Five seams of lignite, as seen by the sequence obtained at Samson's and Saddle Hill Collieries, appear to occur in this area, the lowest of which is at present being wrought, the overlying seams being inferior in quality (in some instances they contain wood almost unchanged), and generally considered too thin to allow of safe workings in accordance with the mode adopted at present.

The collieries here give employment to 90 miners, who are estimated to hew upon an average from two to two and a half tons per day, an equivalent to 60s. per week.

The coal wrought is the dearest won coal throughout New Zealand, as may be observed from the table appended.

While here my attention was drawn to a new industry in the manufacture, by a Mr. Hibbard, of concrete bricks from the quartz sands

overlying the coal. I understand that in Dunedin these bricks are coming largely into favour with architects and others, and I forward one of them labeled with particulars of the advantages claimed for them by the manufacturer.

TABLE

GIVING COSTS AND OTHER PARTICULARS OBTAINED AT THE VARIOUS COLLERIES VISITED THROUGHOUT NORTH AND SOUTH ISLAND, FROM JANUARY TO JULY, 1877.

NAME OF COLLIERY.	Time Working.	Description of Coal.	Thickness.	Total Output.	System of Work.	Thickness, Wrought.	Quantity won per Man per Day.	Number of Men employed.	COSTS. Large, Per Ton.	COSTS. Small, Per Ton.	COSTS. Slack, Per Ton.	REMARKS.
	Years		Ft.	Tons.		Ft.	Tons					
GREEN ISLAND DISTRICT—												
Otago Colliery	3	Brown	16	..	Room & Rance.	6	2 to 2½	9	4/6	3/10	1/-	Slack thrown to waste. Declined to give Output.
Freeman's Colliery	1½	,,	16	5,515	,, ,,	6	,,	18	4/6	3/6	¾	Slack thrown to waste.
Samson's Colliery	3	,,	18	27,000	,, ,,	6	,,	18	4/6	3/10	1/-	,, ,, ,,
Walton Park Colliery ..	7	,,	18	71,000	,, ,,	6 to 8	,,	41	4/6	3/6	1/9	,, ,, ,,
Saddle Hill Colliery	2	,,	18	14,000	,, ,,	6 to 7	,,	9	4/6	3/6	¾	,, ,, ,,
KAITANGATA DISTRICT—												
Kaitangata Colliery	..	Pitch	27	10,000	,, ,,	8	3 to 4	41	3/9	3/-	0/8	Slack, part sold, remainder thrown to waste.
WESTLAND DISTRICT—												
Brunner Colliery	..	Bituminous	18	..	Stoop & Room	..	4 to 5	..	2/9	..	..	Given as informed. Slack used for coke.
Heath Colliery	..	,,	18	..	..	..	..	..	..	..	..	
Greymouth Colliery ..	..	,,	17	..	..	..	..	..	..	..	..	
WAIKATO DISTRICT—												
Kupa-Kupa Colliery ..	..	Brown	18	..	Post & Stall	18	4 to 5	..	3/2	..	..	Slack thrown to waste.
Ralph's Colliery	..	,,	36	..	,, ,,	18	,,	..	3/-	..	..	,, ,, ,,
Bridgewater Colliery ..	..	,,	54	..	,, ,,	18	,,	..	3/-	2/-	..	,, ,, ,,
WHANGAREI DISTRICT—												
Walton's Colliery	..	Pitch	10	..	Stoop & Room	10	,,	..	2/6	1/9	¾	,, ,, ,,
Kamo Colliery	..	,,	14	..	,, ,,	12	,,	..	2/3	1/6	¾	,, ,, ,,
BAY OF ISLAND DISTRICT—												
Kawa-Kawa Colliery ..	..	Glance	12	..	,, ,,	12	3 to 4	..	4/2	3/6	¾	Greater part of slack sold.

REPORT ON RICHMOND HILL SILVER MINE,

BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT GEOLOGIST.

July 21st, 1877.

I have the honor to inform you that I have visited the Richmond Hill Silver Mine at Collingwood, and find that the following operations have been carried on there with a view of prospecting the mine.

The outcrop which it was decided to open upon occurs on the banks of the Para Para River, about five miles from the mouth, the lode here striking about N.—S., and dipping to the east at a very high angle from 87° to 89°. This outcrop, which I reported on in November, 1875, gave good assays for silver at a few feet below the surface, returning as much as 593 ounces per ton of ore.

My advice concerning the prospecting of this mine, as will be seen by reference to the report above referred to, was to bench back on the hill at such an elevation as would render the workings secure from freshets in the river, and then sink so as to intersect the lode at a point 15 or 16 feet below the river bed.

My advice was not followed, but some months' work was first expended in examining the country above water level, after which it was decided to sink.

A shaft was accordingly commenced about 40 feet S. 20° E. of the outcrop on the strike of the lode, and this shaft was sunk on the lode to a depth of 56 feet, where a level was entered along the strike of the lode in a northerly direction, carrying ore for a distance of 36 feet, but of a different character to that which was discovered at the surface.

From this drive five tons of the ore, which had changed to an argentiferous *galena*, were got out, averaging 40 ounces of silver per ton, and three cwt., which averaged 300 ounces.

After driving for 26 feet the lode became barren, and continued so for the next 12 feet, after driving which it was decided to abandon this level, principally, I am given to understand, from fear of the water from the river getting into the mine. This level then never reached a point below the original outcrop by about two feet, and was abandoned

without proving anything beyond the fact that the lode was well defined, was from 20 inches to two feet wide, and carried strings of ore varying a good deal in character.

The shaft was next sunk 50 feet deeper, and at this, 106 feet level, it was the intention of the company to drive below the river; but it was found here that the lode was split by a horse at a few feet to the northward of the shaft, carrying pyrites on the east side and galena on the west. Twenty-three feet only was driven to the north; and to the south, where the lode was united and carried galena, 12 feet only was driven.

After this work had been done at considerable expense, it was decided to sink on the outcrop, and accordingly a shaft has been put down, following the lode to a depth of 20 feet.

The lode is well defined in this shaft from top to bottom, carrying for the first 16 feet the rich silver ore which is found on the surface in strings, from three inches to seven inches in thickness, after which a barren part of the lode of about two feet is passed, the argentiferous ore appearing to hold for a greater depth on the northern side of the shaft than on the southern side, and when this barren patch is passed the character of the ore has changed, and a very fine-grained *galena* is met with, giving about 90 ounces of silver per ton of ore.

This shaft will now have to be abandoned, as it is too near the water's edge to allow of safe working, but it has been of service in showing that the rich ore holds for a depth of about 16 feet here, and appears to deepen in a northerly direction, and also, as this shaft has been exceptionally dry, it will give confidence to the directors of the company to continue their 56 feet level.

At present I should recommend that this 56 feet level be continued for some distance, and that cross-cuts be put in after driving for a few feet, to intersect parallel lodes in the vicinity, of which three or four may be seen at the surface, although their mineral charcter is unknown. A similar procedure might with advantage be carried on in the lower level, but, as I understand the capital of the company is limited, I should recomend the thorough proving of the 56 feet level, before capital is expended below, as, if the ore can be shown to exist in quantity in the mine, there would, I presume, be little difficulty in raising additional capital to work it.

There has, I believe, been some talk of erecting smelting works at the mine, which for the present I should strongly discountenance, as also the erection of any surface plant for dressing the ore, for I do not consider that the extent or value of the ore has been sufficiently proved up to the present time to justify any expense being gone to in that class of work.

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Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S.,
DIRECTOR.

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